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Characteristics of conventional blood pressure in studies on the predictive power of ambulatory blood pressure

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Background It is commonly believed that the associations of left ventricular mass and cardiovascular morbidity/mortality with blood pressure are stronger for 24-h ambulatory pressure than for conventional clinic or casual pressure.

Methods The investigation comprised a review of relevant studies, with particular emphasis on the characteristics of the conventional blood pressure measurement.

Results A review of 21 studies on left ventricular mass, published between 1982 and 1993, showed that the relationship between mass and blood pressure was stronger for ambulatory blood pressure than for clinic blood pressure but that the methodology and conditions of the conventional blood pressure measurements were poorly described or standardized in several reports. Between 1983 and 2001, seven studies showed that ambulatory blood pressure was superior to conventional blood pressure with regard to the prediction of cardiovascular morbidity and/or mortality. From published data and requests for additional information, it appears that recommendations for the measurement of conventional blood pressure have been reasonably well observed, although the number of measurements has not always been adequate.

Conclusions Whereas the quality of the conventional blood pressure measurements left much to be desired in the studies on left ventricular mass, the quality appeared to be reasonably good in outcome studies, even though the published details were often incomplete. *Blood Press Monit* **7**: 33–36 © 2002 Lippincott Williams & Wilkins.

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Keywords: ambulatory blood pressure, cardiovascular events, clinic blood pressure, mortality, prognosis

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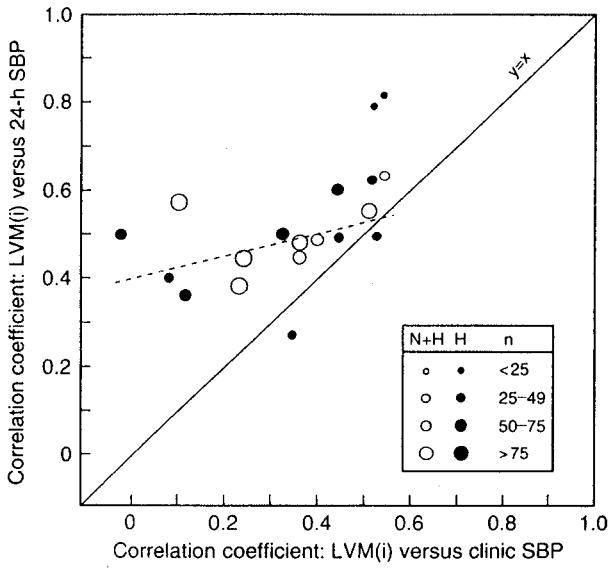
Introduction

High blood pressure is associated with increased cardiovascular morbidity and mortality. Before severe complications such as stroke, myocardial infarction or renal insufficiency occur, less dramatic manifestations of target organ damage such as left ventricular hypertrophy and proteinuria may develop. Most studies rely on conventional clinic or casual blood pressure measurements. There are, however, several drawbacks to this method, such as the limited number of blood pressure measurements, the small fraction of the day during which they are measured and the white-coat effect. To overcome these inconveniences, home blood pressure measurement by the patient has been proposed, and fully automated non-invasive blood pressure measuring devices have been developed that allow intermittent pressure measurements to be made during both day and night. One area of potential interest is that mean 24-h ambulatory blood pressure might be better related than conventional blood pressure to target organ damage, morbidity and mortality. Before accepting that ambulatory blood pressure is superior to clinic or casual blood pressure in this respect, however, a critical examination of the way in which conventional blood pressure has been measured in such studies is warranted.

Left ventricular mass

The most frequently studied surrogate or intermediate end-point is left ventricular mass. We reviewed the data on the relationships between echocardiographic left ventricular mass and clinic and ambulatory blood pressure, respectively, from 21 comparative studies published between 1982 and 1993 [1]. The weighted correlation coefficient, which averaged 0.35 for systolic clinic pressure, was significantly ($P<0.001$) higher for the average 24-h ambulatory systolic pressure ($r = 0.50$). The coefficients averaged 0.32 and 0.44, respectively, for diastolic pressure ($P < 0.01$). However, the results varied greatly among studies, and in a further analysis we examined the relationship between the correlation coefficient of left ventricular mass against 24-h blood pressure and the correlation coefficient of left ventricular mass against clinic blood pressure. Figure 1 indicates that the improvement in strength of the relationship between left ventricular mass and ambulatory blood pressure, compared with clinic pressure, is most pronounced when the correlation coefficient for the relationship with clinic blood pressure is low, and that there is no obvious gain from ambulatory blood pressure monitoring when the correlation coefficient

Fig. 1



Relationship between the correlation coefficients of left ventricular mass (LVM) and 24-h systolic blood pressure (SBP) and clinic systolic blood pressure, respectively. ○, Normotensive and hypertensive subjects combined; ●, hypertensives only. The size of the circle refers to the number of participants (*n*). The regression line is derived from weighted single regression analysis ($Y = 0.40 + 0.26 \times X$; $P = 0.06$) and crosses the line of identity at $r = 0.55$. Reprinted by permission of Elsevier Science from (Fagard R *et al.*, Multiple standardized clinic blood pressures may predict left ventricular mass as well as ambulatory monitoring. A meta-analysis of comparative studies.) *American Journal of Hypertension*, **8**, 533–540, Copyright 1995 by *American Journal of Hypertension* [1].

for the relationship with clinic pressure is already approximately 0.50.

It is tempting to speculate that the variable strength of the relationship between left ventricular mass and clinic blood pressure relates to different number of measurements and variable degrees of standardization, but this is difficult to prove from reported studies because details of the clinic blood pressure measurements in terms of methodology and conditions, number of observers involved, number of pressure measurements and visits, and time of the day have often not been reported (Table 1). In several studies, these pressures were only vaguely described as 'clinical blood pressure readings measured by physicians', 'the mean of three blood pressure measurements', 'clinic rest blood pressure', 'casual blood pressure' and 'office blood pressure', without further detail. Several individual studies suggest that the relationship between left ventricular mass and ambulatory blood pressure is not necessarily superior to the relationship with clinic pressure when an adequate number of blood pressures are measured in the clinic in well-standardized conditions [2–4].

Table 1 Percentage of studies lacking data on characteristics of conventional blood pressure measurement as seen in 21 studies that compared the association between left ventricular mass and conventional and ambulatory blood pressure, respectively [1]

Characteristic not reported	Percentage of studies
Measurement technique	38
Position of the subject	33
Number of observers	79
Number of visits	33
Number of blood pressure measurements per visit	57
Total number of blood pressure measurements	52
Time of the day	86

In a subsequent study, we performed echocardiography, ambulatory blood pressure monitoring and repeated clinic blood pressure measurement in well-standardized conditions in patients with essential hypertension [5]. Clinic blood pressure was measured five times on two different days. The correlation coefficient for the relationship between left ventricular mass and clinic pressure increased with an increasing number of measurements. Furthermore, when the 10 clinic measurements were averaged, the variance of left ventricular mass explained by 24-h ambulatory blood pressure in addition to clinic pressure was not significant for systolic pressure and amounted to only 3% for diastolic pressure. Therefore increasing the number of measurements strengthens the relationship between clinic pressure and left ventricular mass and, conversely, diminishes the additional predictive power of 24-h blood pressure.

Recommendations for the clinic blood pressure measurement

These observations raise the following question: with which quality standards should clinic blood pressure comply before one accepts that ambulatory blood pressure is superior to clinic pressure? We suggested a critical examination of the quality of clinic blood pressure measurement in reports on the relationship between ambulatory pressure and target organ damage or on the prognostic importance of ambulatory blood pressure compared with clinic blood pressure measurement [5]. A reasonable requirement would be for clinic blood pressure to comply with the criteria put forward in commonly accepted guidelines [6–8]. This involves repeated blood pressure measurements, i.e. the average of at least two readings, separated by 2 min, on each of at least two visits after an initial screening visit [6], multiple blood pressure measurements taken on several separate occasions [7] or two measurements at each of several visits [8]. Guidelines suggest measurements in the seated position after several minutes of rest; measurements can be made in the supine or standing position if indicated. Blood pressure should be measured using a mercury sphyghmomanometer or another calibrated and validated device, using an appropriately sized cuff.

Cardiovascular morbidity and mortality

The predictive power of ambulatory blood pressure in comparison with conventional blood pressure with regard to cardiovascular morbidity and mortality has been assessed in seven studies currently published in peer-reviewed journals [9–18]. These studies were performed in the general population [12], in hypertensive individuals in general [9–11,13,15,18], in patients with isolated systolic hypertension [16,17] and in those with refractory hypertension [14]. The final results of the recently completed OvA study of hypertensives undergoing pharmacological treatment [19] have not yet been published. Some studies reported that white-coat hypertension was associated with a better outcome than sustained hypertension on ambulatory blood pressure monitoring [11,13,17,18]. Others found that the predictive value of ambulatory monitoring persisted after control for conventional clinic or casual blood pressure [9,10,12,14–16]. The superiority of ambulatory over conventional blood pressure monitoring was shown for combined fatal and non-fatal cardiovascular events [9–17], for stroke [17,18], for cardiovascular mortality [9–12,16] and for all-cause mortality in the Syst-Eur trial [16].

In a first step in the quality assessment of the conventional blood pressure measurements, several characteristics were tabulated as reported in the manuscripts. Thereafter, the corresponding author was contacted to check the data and to give additional information on features of the measurements that had been lacking in the main manuscript. Table 2 summarizes the measurement characteristics, with mention of those obtained by 'personal communication' and the few still-absent details.

Several studies used a mercury sphygmomanometer; in one the measurement was described as being made by the 'conventional auscultatory technique', and two used automatic devices. Cuff size was usually appropriate, or described as 'standard' in the Japanese studies. Blood pressure was measured in the sitting position, except in one study, in which the supine position was used, after a rest period of at least 2 min, but usually after 5 or more minutes. Blood pressure was measured by a variable number of physicians, nurses and technicians, mostly in the office, hospital or clinic, except for the one population study, in which blood pressure was measured in a health check-up center. More than one center was involved in several studies. The number of visits was at least two and mostly three, except for the single visit in the Japanese population study. Blood pressure was measured at least twice per visit, except in two studies, and the interval between measurements was 30 s or more. The total number of measurements was at least five, except in the one population study and in two hospital-based studies. Blood pressure was measured according to recommended guidelines in several reports.

Table 2 Characteristics of the conventional clinic or casual blood pressure measurement in studies on the prognostic significance of ambulatory blood pressure monitoring

	Device	Cuff size	Position	Rest period	Observer(s)	Site (*n*)	No. of visits	No. of measurements			Time period	Observed guidelines
								No./visit	(interval)	Total no.		
Perloff *et al.* [9,10]	HgSph	Appr	Sit[a]	~≥5 min[a]	Ps	O,C	~3	3–5[a]	(±0.5 min[a])	≥5	~4–6 weeks[a]	'recommended techniques'
Verdecchia *et al.* [11]	HgSph[a]	Appr[a]	Sit	≥5 min[a]	Ps[a]	H (3)	≥3	3–5[a]	(1–5 min[a])	≥9[a]	3 weeks	~BHS[a]
Ohkubo *et al.* [12]	VFA	Stan	Sit	≥2 min	Ns, Ts	HCUC[a]	1	2	(0.5–1.0 min[a])	2	NA	JNC, WHO–ISH[a]
Khattar *et al.* [13,15]	CAT	?	Sup	5–10 min	Ns, Ts	H (1)	≥2	1	(NA)	≥2	≤4 weeks	?
Redon *et al.* [14]	HgSph	Appr[a]	Sit	5 min	Ps[a]	OPC (2)	3	3	(5 min)	9	~2 months	BHS
Staessen *et al.* [16]	HgSph	Appr	Sit	5 min	Ps, Ns	Syst-Eur Centers (46)	3	2	(1 min)	6	~2 months	BHS
Fagard *et al.* [17]												
Kario *et al.* [18]	Aut[a]	Stan[a]	Sit	≥5 min	Ns[a]	C, H, OPC (6)	≥2	1[a]	(NA)	≥2[a]	≥1 week[a]	JNC, WHO–ISH[a]

Appr, appropriate; Aut, automated; BHS, British Hypertension Society; C, clinic; CAT, conventional auscultatory technique; H: hospital; HCUC, health check-up center; HgSph, mercury sphygmomanometer; JNC, Joint National Committee; NA, not applicable; Ns: nurses; O: office; OPC, outpatient clinic; Ps, physicians; Sit, sitting; Stan, standard; Sup, supine; Ts, technicians; VFA, validated fully automatic; WHO–ISH: World Health Organization–International Society of Hypertension. [a]Personal communication; ?, Unknown.

It can be concluded from published data and personal communications that recommendations for the measurement of conventional blood pressure appear to have been reasonably well observed in the outcome studies, although the number of visits or measurements has not always been adequate. The fact that several details of the measurements had to be obtained from the authors indicates that more attention should be paid to the actual description of the qualitative and quantitative characteristics of conventional blood pressure measurement. The accuracy of the details obtained by personal communication could indeed be criticized. Finally, the fact that conventional blood pressure has been measured by different observers in sometimes different centers should be taken into account when interpreting the results.

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