

# Ambulatory blood pressure measurement in the elderly

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A number of problems relating to clinic measurements of blood pressure may be particularly relevant to elderly patients with isolated systolic hypertension. First, there are large discrepancies in the blood pressure levels measured by these two techniques in the elderly population. Second, while blood pressure is universally accepted as one of the most important risk factors for the development of cardiovascular morbidity, its predictive value in the individual is relatively poor.

Clinic and 24-h ambulatory recordings from 318 patients aged 17–80 years, diagnosed as having isolated systolic hypertension on clinic measurement, were compared with reference values determined from 815 healthy bank employees. In the isolated systolic hypertension group, mean systolic blood pressure by daytime ambulatory measurement was 27 mmHg lower than that recorded in the clinic, while diastolic pressure was similar ( $151 \pm 17/87 \pm 11$  versus  $178 \pm 28/84 \pm 9$  mmHg). This discrepancy was greater in women than men, increased slightly but significantly with age ( $r = 0.12$ ,  $P < 0.05$ ) and raised the crucial question as to which of the two measurements might best predict prognosis in this population.

In a further study of the association between electrocardiographic (ECG) voltages and blood pressure measured in the clinic and by ambulatory monitoring in 216 patients with isolated systolic hypertension, the sum of  $SV_1 + RV_5$  and the sum of  $SV_1 + RV_6$  were significantly and positively related to systolic pressure both in the clinic and with daytime and night-time ambulatory measurement. In addition, we calculated residual ambulatory blood pressure, defined as the difference between the observed ambulatory blood pressure and the blood pressure predicted from the linear regression equation relating clinic blood pressure to the blood pressure on ambulatory measurement, to determine whether ambulatory blood pressure measurement improved the estimate of ECG voltages based on the clinic measurement alone, and we found that most of the correlations remained significant.

There are marked discrepancies between blood pressure measured in the clinic and with ambulatory blood pressure monitoring in elderly patients with isolated systolic hypertension. While both methods predicted left ventricular hypertrophy as assessed by ECG voltage criteria, the ambulatory measurement added further accuracy to the prediction of left ventricular hypertrophy already provided by the clinic measurement. These findings require confirmation in a prospective trial such as the secondary project on ambulatory monitoring in the Syst-Eur Study.

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## Introduction

Non-invasive ambulatory blood pressure measurement is being used increasingly in recent years. The technique is now gaining acceptance in clinical practice and may be especially useful in the evaluation of

patients with borderline hypertension [1]. The further development of this technique in clinical diagnosis has been enhanced by the recent publication of reference values [2,3]. Moreover, the technique is being used increasingly in the assessment of antihypertensive drug efficacy [4].

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In this paper, we discuss the changes that occur in ambulatory blood pressure monitoring values with age. Because isolated systolic hypertension affects between 10 and 20% of the elderly [5], special emphasis is placed on this condition. Indeed, the growing awareness among physicians that systolic hypertension carries a greater risk in the elderly than diastolic blood pressure elevation has generated much interest in the diagnosis and treatment of this form of hypertension [5].

Since age and blood pressure are continuous variables with no discernible transition points, arbitrary definitions must be used for classification. Isolated systolic hypertension, unless otherwise specified, is arbitrarily defined as a systolic pressure of 160 mmHg or greater with a diastolic pressure below 95 mmHg [6], although other definitions are used. For example, in the Systolic Hypertension in the Elderly Programme (SHEP), 90 mmHg was used as the diastolic cut-off point [7].

### **Ambulatory versus conventional blood pressure measurement**

The procedure for measurement of blood pressure by conventional sphygmomanometry is replete with sources of potential error and some of these apply to non-invasive ambulatory monitoring but with the important exception that inaccuracy related to the observer, i.e. systematic error, terminal digit preference and observer prejudice, are eliminated. Also, the technique provides multiple measurements over the course of the 24-h period.

There are additional problems relating to clinic measurement of blood pressure which may be particularly relevant to the elderly. First, there are large discrepancies in the blood pressure levels measured by these two techniques in older patients with isolated systolic hypertension [8]. Also, while blood pressure is universally accepted as one of the most important risk factors in the development of cardiovascular morbidity, its predictive value in the individual is relatively poor [9]. This, together with the relatively disappointing reduction in coronary artery events and the significant impact of adverse drug reactions in the major clinical trials of the treatment of hypertension in the elderly, has placed a new emphasis on the need to identify high-risk patients, so that they can be targeted for assertive management.

### **Clinic versus ambulatory blood pressure**

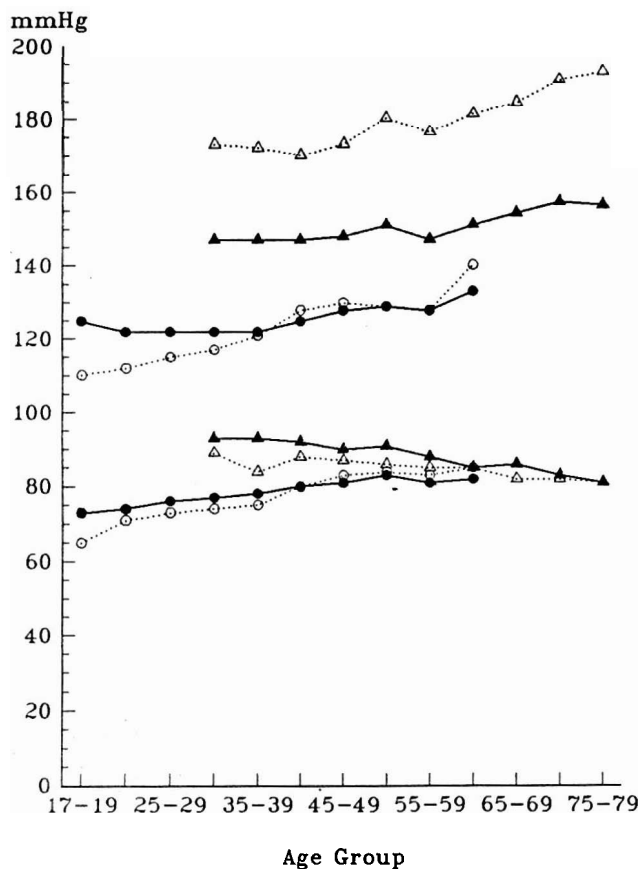
In a recent study, confined to patients over 70 years of age, a discrepancy of 24 mmHg was reported between clinic and daytime ambulatory systolic blood

pressure (176/82 versus 152/86 mmHg) in 10 patients with isolated systolic hypertension (systolic pressure greater than 160 mmHg and diastolic pressure less than 90 mmHg) [8]. We have further investigated this phenomenon by carrying out a retrospective study of the patients with isolated systolic hypertension in our blood pressure clinic database [10]. Clinic (standard mercury sphygmomanometer) and 24-h ambulatory (SpaceLabs 90202; Redmond, Washington, USA) recordings from 318 patients, 17–80 years of age, diagnosed as having isolated systolic hypertension by clinic measurement, were compared with reference values determined from 815 healthy bank employees.

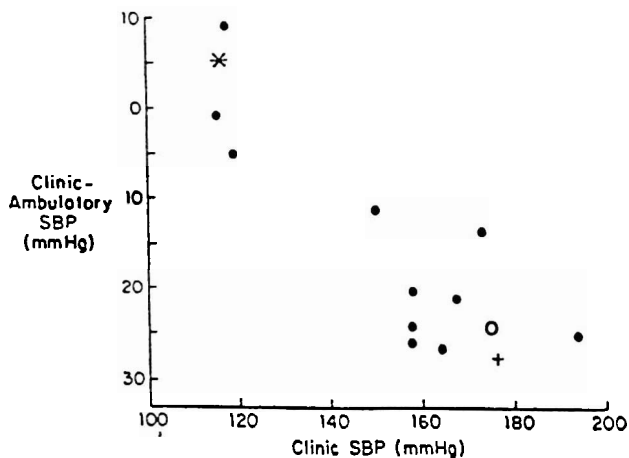
Systolic and diastolic pressures by clinic and ambulatory measurement for both groups are shown in Fig. 1. In the group with isolated systolic hypertension, mean systolic blood pressure by daytime ambulatory measurement was 27 mmHg lower than that recorded in the clinic, while the diastolic pressures were similar ( $151 \pm 17/87 \pm 11$  versus  $178 \pm 28/84 \pm 9$  mmHg). Blood pressure levels were similar with both methods of measurement in the healthy normotensive population ( $124 \pm 12/78 \pm 8$  versus  $119 \pm 15/76 \pm 10$  mmHg). The discrepancy observed here for patients with isolated systolic hypertension was greater in women than men, increased slightly but significantly with age ( $r = 0.12$ ,  $P < 0.05$ ), but was not related to the body mass index or to drug treatment.

The relationship between clinic and daytime ambulatory pressures has been reviewed in some detail by Pickering and James [9]. The finding that daytime ambulatory pressures in hypertensive patients are usually lower than clinic pressures has been confirmed in a number of studies. The results of some of these and of the present study are plotted in Fig. 2. In studies of normotensive patients, only slight differences in blood pressure between daytime ambulatory readings and measurements taken by an observer were reported [2,11]. Thus, in a population sample of 238 healthy subjects aged 20–79 years from a small Belgian town, daytime ambulatory blood pressure was, on average, 5/4 mmHg higher than blood pressure measured at home [11], in keeping with the differences reported in our control population [2]. In a retrospective analysis similar to the present study, where the clinic population was divided into 'hypertensive' (clinic blood pressure greater than 160/90 mmHg) and 'normotensive' patients, daytime ambulatory blood pressure in the hypertensive group was 22/4 mmHg lower than clinic blood pressure [12]. However, in the normotensive patients, daytime ambulatory blood pressure was 4/10 mmHg higher than clinic blood pressure. These data are in agreement with ours and the findings of a number of smaller prospective studies [13–18].

As the discrepancy between clinic and daytime ambulatory blood pressure recording is greater in patients with higher clinic pressures, greater for systolic



**Fig. 1.** Systolic and diastolic pressure by clinic and daytime ambulatory measurement for normotensive subjects and patients with isolated systolic hypertension plotted against age. ○···○, Clinic blood pressure in normotensive subjects; ●—●, ambulatory blood pressure in normotensive subjects; △···△, clinic blood pressure in isolated systolic hypertensive patients; ▲—▲, ambulatory blood pressure in isolated systolic hypertensive patients.



**Fig. 2.** Comparison of average levels of clinic and daytime ambulatory systolic blood pressure (SBP) from nine published studies, three of which included more than one group of subjects: ●, [14-19]; \*, Allied Irish Banks Study [2]; +, isolated systolic hypertensive patients [10]; ○, isolated systolic hypertensive patients [8].

pressure and may be, to some extent, age-related,

these findings assume special importance for the older patients with isolated systolic hypertension. Since hypertension, irrespective of age, is conventionally defined by the level of pressure measured in the clinic, individual patients who show an exaggerated blood pressure response in the clinic setting will be identified as hypertensive.

Mancia *et al.* [19] evaluated the alarm reaction or white-coat effect in younger hypertensive patients in the inpatient hospital setting using intra-arterial monitoring. They found no relationship between the magnitude of the response and blood pressure level or age. There are few data on the effect of the presence of the doctor on blood pressure levels in older patients attending outpatient clinics. Of particular interest is a recent paper from Japan describing blood pressure levels monitored non-invasively in hypertensive patients at 5-min intervals for the duration of an outpatient clinic visit [20]. Systolic and diastolic blood pressures increased by 17 and 7 mmHg, respectively, while the patient was in the presence of the doctor, and fell to baseline levels approximately 40 min later.

The anxiety associated with a clinic visit is one possible explanation for the discrepancy in systolic blood pressure levels by the two methods of measurement, but other factors may be involved, such as the effect of the doctor-patient relationship on the patient's blood pressure [9]; this hypothesis has not yet been tested in the elderly.

### Ambulatory measurement as a predictor of risk

In the assessment of the elderly patient with hypertension, the diagnostic task is mainly concerned with quantifying the level of blood pressure and deciding whether the patient with elevated blood pressure is at sufficiently high cardiovascular risk to warrant treatment. There is a large body of information available on this subject, but most is derived from clinic measurements which, though giving a good estimate of risk for the population as a whole, do not predict well for the individual patient [9]. It is pertinent, therefore, to ask whether any additional clinical information, such as that obtained from ambulatory blood pressure monitoring, may be useful in predicting risk. Unfortunately, there are few prospective studies on these techniques. The only large-scale prospective study published so far is that of Perloff *et al.* [21], which suggested that ambulatory measurement of blood pressure was a better predictor of cardiovascular mortality and morbidity than clinic pressure alone. These findings, however, applied only to patients with mild hypertension (diastolic pressures <105 mmHg) with no previous cardiovascular morbid events and under 50 years of

age. An increasing number of other studies, which have been extensively reviewed elsewhere [22], have demonstrated that ambulatory pressure can be correlated more closely than clinic pressure with several different indices of target-organ damage in young and middle-aged patients. However, to date, no data are available for the elderly in general or those with isolated systolic hypertension in particular.

For this reason we examined the association between electrocardiographic (ECG) voltages and blood pressure measured in the clinic (standard mercury sphygmomanometer) and by ambulatory measurement (SpaceLabs 90202) in 216 patients, aged 17–80 years, found to have isolated systolic hypertension by clinic measurement [23]. Voltages were higher in men than in women, were negatively correlated with the body mass index and were unrelated to age. Partial correlation coefficients (corrected for age, sex and body mass index) relating clinic and ambulatory blood pressures to ECG voltages were calculated. The unique contribution of ambulatory blood pressure levels to the prediction of left ventricular hypertrophy was assessed by calculating the 'residual' ambulatory blood pressure. This is the difference between the observed ambulatory blood pressure and the blood pressure predicted from the linear regression equation relating clinic blood pressure to the blood pressure on ambulatory measurement for each patient in the entire sample.

In the present study, the sum of  $SV_1 + RV_5$  and the sum of  $SV_1 + RV_6$  was significantly and positively related to systolic pressure, both in the clinic and with daytime and night-time ambulatory blood pressure monitoring (Table 1). The finding that most of the correlations between residual ambulatory blood pressure and the ECG voltages remained significant indicates that, in this population, ambulatory measurement adds to the prediction of left ventricular hypertrophy provided by clinic measurements.

**Table 1.** Partial correlation coefficients<sup>†</sup> relating clinic and ambulatory blood pressure to ECG voltage.

	Clinic		Daytime ABP		Night-time ABP	
	SBP	DBP	SBP	DBP	SBP	DBP
Clinic and ambulatory blood pressures:						
$V_1 + V_5$	0.38***	0.13*	0.27***	-0.01	0.31***	0.11
$V_1 + V_6$	0.42***	0.13	0.36***	0.02	0.36***	0.13
Residual ambulatory blood pressure						
$V_1 + V_5$	-	-	0.12	-0.05	0.18**	0.08
$V_1 + V_6$	-	-	0.20**	-0.02	0.22***	0.10

\* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$ . <sup>†</sup>Corrected for age, sex and body mass index. SBP, systolic blood pressure; DBP, diastolic blood pressure; ABP, ambulatory blood pressure; ECG, electrocardiographic.

These findings are based on the results of a retrospective study and require confirmation in a prospec-

tive study. More importantly, a prospective study is also required to assess the relative predictive values of clinic and ambulatory blood pressure monitoring for cardiovascular morbidity and mortality in elderly patients with isolated systolic hypertension. It is therefore hoped that the secondary project on ambulatory monitoring in the Syst-Eur Study [24] will provide some much needed answers to these questions.

### The Syst-Eur Study secondary project on ambulatory blood pressure monitoring

The Syst-Eur Study is a multicentre trial designed by the European Working Party on High Blood Pressure in the Elderly to test the hypothesis that antihypertensive treatment reduces cardiovascular morbidity and mortality in elderly patients with isolated systolic hypertension [25]. In this study, patients aged 60 years or more with a systolic blood pressure of 160–219 mmHg and a diastolic pressure of less than 95 mmHg will be randomly allocated to either active treatment with nitrendipine, enalapril and hydrochlorothiazide added in a stepwise fashion or treatment with placebo.

The secondary project on ambulatory blood pressure measurement is an optional part of the main Syst-Eur Study with the primary objective of testing the hypothesis that ambulatory blood pressure monitoring adds to the prediction of cardiovascular complications of hypertension obtained by clinic blood pressure measurements. Ambulatory blood pressure monitoring performed during the placebo run-in phase will be correlated with the incidence of cardiovascular events occurring in the trial. This project will also provide an opportunity to compare the techniques of clinic and ambulatory measurement and to evaluate the effects of treatment on the 24-h blood pressure profile in elderly patients with isolated systolic hypertension.

### Conclusion

There are marked discrepancies between blood pressure measured in the clinic and by ambulatory blood pressure monitoring in elderly patients with isolated systolic hypertension. These findings raise the crucial question as to which of the two measurements best predicts prognosis in this population. On the basis of our findings to date, it appears that both methods predict left ventricular hypertrophy as assessed by ECG voltage criteria. In addition, we have shown that in this population, ambulatory measurement adds to the prediction of left ventricular hypertrophy provided by clinic measurement. It is hoped that these findings will be confirmed in a prospective study such as the sec-

ondary project on ambulatory monitoring in the Syst-Eur Study in the near future.

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