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ORIGINAL ARTICLE

Arterial hypotension: prevalence of low blood pressure in the general population using ambulatory blood pressure monitoring

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Background: **Chronic constitutional hypotension has been described in a proportion of the population, and has a symptom complex ascribed to it. The true prevalence of low blood pressure in the normal population has not been defined.**
Aim of study; **This study was undertaken to determine the prevalence of low blood pressure states, as measured using ambulatory blood pressure monitoring, in a general population cohort, and to determine the association between low blood pressure and clinical and demographic variables.**
Patient population: **The population enrolled were a cohort of mainly urban dwelling Irish subjects, either employees or spouses of employees of a major national bank.**
Methods: **Subjects had an ambulatory blood pressure monitor fitted between 09.00 and 12.00 and wore the monitor for 24 hours. The subjects also filled out a detailed lifestyle questionnaire, and kept an activity diary. Blood was drawn for serum electrolyte estimation.**
Results: A total of 254 subjects were included, 49% of whom demonstrated hypotensive events. Hypotensive means and individual hypotensive values were more frequently found in women, and occurred in a group of individuals with a distinct body habitus, specifically thin subjects, with a lower creatinine suggesting a smaller muscle mass. Hypotensive events in these subjects were associated with a low risk cardiovascular profile, in that subjects who displayed these events had a lower blood pressure, a lower weight and were less likely to have a positive family history of hypertension or vascular disease.
Conclusion; **Hypotension is common in the general population and is associated with a distinct body habitus. It carries a generally benign cardiovascular risk factor profile.**
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Keywords: hypotension; ambulatory blood pressure monitoring: prevalence

Introduction

Arterial hypotension is most widely recognized in the elderly, or in patients with significant impairment of autonomic reflexes.[1] A significant body of scientific work exists on the topic of orthostatic hypotension and some drug and non-drug treatments exist for its management.[2] Less well understood however is the concept of chronic constitutional hypotension, and there is a paucity of scientific work on the subject. Nevertheless, it is a frequently diagnosed complaint in the minds of the lay public, and symptoms of fatigue, anergy and dizziness are not infrequently attributed to hypotension. Physicians in some European countries do view chronic low blood pressure as a disease entity, and drug treatments do exist.[3] However, it remains a poorly explored subject.

Ambulatory blood pressure monitoring has significant advantages in the investigation of low blood pressure.[4] It is relatively free of the white coat effect, and therefore more likely to give a true reflection of ambient blood pressure for a given individual during the course of the day and night. Furthermore, it allows an assessment of blood pressure that is closely allied to an individuals behaviour, and which can be closely monitored using an accurately kept symptom diary. Finally, it gives information on night-time blood pressure, when blood pressure is at its lowest.

To provide a framework for further study of this neglected aspect of blood pressure research, we undertook to examine the prevalence of chronic constitutional hypotension in a large general population, using the technique of ambulatory blood pressure monitoring. Specifically we examined the distribution of low blood pressure means for daytime and night-time periods, and examined the prevalence and associated variables of hypotensive events in these subjects.

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Subjects and methods

Study population

The study population comprised subjects enrolled into the Allied Irish Bank (AIB) phase two study. This is a study of blood pressure in an Irish, largely urban population, drawing on the staff and families of a national bank. The first AIB study[5] helped to set the upper limits of normal for ambulatory blood pressure in the general population. The original study cohort of 815 subjects were contacted an average of 5 years later, and asked to participate in a follow-up study. Patients agreeing to re-participate underwent repeat ambulatory blood pressure monitoring and blood testing for biochemical parameters. Subjects also filled out a detailed lifestyle questionnaire. All subjects attending for repeat monitoring were enrolled into this study; the only specific exclusion criteria for participation in this study was concomitant use of blood pressure lowering drug therapy. Untreated hypertensives were included in the analysis.

Ambulatory blood pressure monitoring (ABPM)

ABPM was performed using the SpaceLabs 90207 ambulatory blood pressure monitor (Redmond, WA, USA).[6] This was fitted to the non-dominant arm after arm measurement for appropriate cuff size, and the monitor was programmed for measurement at 30-min intervals day and night. The subject was instructed to continue life as normal between readings, but to rest the arm at heart level during readings. Subjects were also asked to keep an accurate symptom diary, reporting activity at each measurement. They were also asked to note down the time of retiring and time of rising. The initial, daytime and night-time systolic, diastolic and mean blood pressures were calculated. The daytime and night-time periods were calculated on the basis of the rising and retiring times noted in the symptom diary. Subjects were asked to comment on the quality of the night-time sleep. The monitor was removed the next day, and the data was retrieved from the ABPM, and immediately loaded into a specialized software database (DABL).[7] All recorded measurements not edited by the monitor software were included in the results.[8]

Blood testing

When the subjects attended for examination and monitor fitting, they had fasting blood drawn for urea, electrolyte and creatinine estimation.

Questionnaire

Subjects completed a lifestyle questionnaire, which asked in detail about smoking and alcohol habits, activity during the course of a normal day, as well as regular exercise, if any. Subjects completed a self-assessment scoring questionnaire for physical activity graded on a scale from 1 to 10, from sedentary to very active, respectively. Excess salt use in the diet was defined as the addition of salt to food at table. Alcohol consumption was quantified as units consumption per week. Smokers were coded according to current or non-smoking status.

Statistical analysis

The analysis was approached in two steps. First, the blood pressure of the population as a whole was assessed, and, in the absence of a recognized lower limit of normal, the lower limit of normal was taken as the fifth percentile of blood pressure appropriate for sex and time of day. Clinical variables in subjects exhibiting hypotensive mean pressures were compared to identify associations with low-pressure states. Secondly, hypotensive events were examined. Hypotensive events were defined as two or more consecutive systolic or diastolic readings below the fifth percentile for sex and time of day. Clinical variables were then examined to determine categorical associations with the occurrence of hypotensive events. Categorical associations were examined using the χ^2 test, or Fishers exact test (FET) where appropriate. Continuous variables were examined using Student's t-test.

Results

A total population of 245 subjects was available for study, representing 30% of the original AIB cohort. Only four patients were excluded from the follow-up study, for concomitant use of blood pressure lowering medications. Males comprised 62.9% of the population, and the mean age for the population as a whole was 47.4 (10.2) (males 48.9 (9.0), females 44.8 (11.6)).

Ambulatory blood pressure means

The 5th, 10th, 50th, 90th, and 95th percentiles of blood pressure in the population are given in Table 1, for the population as a whole and for the sexes individually. Using the fifth percentile as the statistical lower limit of normal gives the lower limit of normal as 115/70 mm Hg and 97/56 mm Hg for male subjects for daytime and night-time respectively, and 105/65 mm Hg and 92/52 mm Hg for female subjects for daytime and night-time respectively.

In females, a daytime systolic hypotensive mean pressure was significantly associated with a daytime diastolic hypotensive mean pressure, and vice versa (P = 0.009, FET), but neither were associated with low nocturnal pressures. Nocturnal systolic or diastolic hypotensive means were not significantly associated with either each other, or diurnal hypotensive means.

Clinical variables between females showing hypotensive means during the day or night were compared (Table 2). Weight was significantly lower in the hypotensive group. There was also a nonsignificant trend towards a negative family history of hypertension. A logistic regression model was fitted to the data to identify significant predictors of hypotension; the presence of a hypotensive mean day or night-time pressure was the dependent variable; age,

Table 1 Percentile ambulatory blood pressure descriptive statistics for total, male and female population. Shaded area shows statistical lower limit of normal for ambulatory blood pressure appropriate for sex and time of day

	Percentile				
	5th	*10th*	*50th*	*90th*	*95th*
Total population					
Day systolic	107.0	111.0	127.0	141.4	149.7
Day diastolic	67.0	68.0	80.0	92.0	94.0
Night systolic	94.0	96.6	108.0	127.0	133.7
Night diastolic	54.0	56.0	64.0	77.0	80.4
Male subjects					
Day systolic	114.7	119.0	130.0	145.5	154.2
Day diastolic	69.7	73.0	83.0	93.5	98.0
Night systolic	97.0	100.0	110.0	129.5	137.25
Night diastolic	56.0	58.0	67.0	78.0	84.7
Female subjects					
Day systolic	104.6	106.0	118.0	137.0	141.0
Day diastolic	64.6	67.0	74.0	86.0	89.0
Night systolic	91.6	93.0	103.0	119.0	127.0
Night diastolic	52.0	54.0	61.0	71.0	77.0

Table 2 Differences in clinical variables between hypotensives and normotensives in females

	Hypotensive	*Non-hypotensive*	*P*
No.	13	78	
Age	44.5 (13.9)	44.9 (11.3)	0.91
Height	165.5 (5.1)	165.0 (6.2)	0.79
Weight	58.4 (5.0)	65.6 (8.9)	0.006
Day systolic BP	111.8 (8.4)	121.3 (11.4)	0.005
Day diastolic BP	68.4 (5.7)	76.0 (7.3)	0.001
Night systolic BP	96.1 (7.1)	106.4 (10.3)	0.001
Night diastolic BP	53.8 (3.3)	63.1 (6.7)	0.0001
Activity	4.4 (1.4)	4.5 (1.2)	0.76
Alcohol	7.8 (7.0)	7.7 (7.8)	0.98
Smoking (y/n)	4/9	15/63	0.27
Excess salt *(y/n)*	7/6	45/33	0.51
Plasma sodium	139.8 (11.0)	143.3 (11.3)	0.3
Creatinine	77.6 (10.6)	80.8 (12.3)	0.15
Family history of BP (yin)	5/8	45/33	0.16
Post-menopausal *(y/n)*	5/8	23/55	0.36
Family history of Vasc D *(y/n)*	7/6	38/40	0.77

BP, blood pressure; Vasc D, vascular disease. Figures in parentheses represent standard deviation of the mean.

height, weight, sodium, potassium, creatinine, and alcohol were entered as dependent variables, and cigarette smoking status, salt use, family history of hypertension or vascular disease and menopausal status (pre- or post-menopausal) were entered as co-variates. Weight remained a significant negative independent predictor of hypotensive blood pressure means in this female population (β = *-0.15,* R = -0.27, P = 0.008).

In the male population, daytime systolic hypotensive means were significantly associated with daytime diastolic hypotensive means (P = 0.034, FET), but neither were associated with nocturnal hypotension. Nocturnal systolic hypotensive mean pressures were associated with nocturnal diastolic hypotensive means (P = 0.01, FET), but again nocturnal pressures were not significantly associated with diurnal hypotensive means.

Table 3 shows the differences between clinical variables for hypotensive and non-hypotensive male subjects. Age was significantly greater in hypotensive males, and these subjects tended not to have a family history of hypertension. A logistic regression model was fitted to the data to identify significant predictors of hypotension; the presence of a hypotensive mean at any time of day was the dependent variable, and age, height, weight, serum sodium, potassium, creatinine, and alcohol were entered as dependent variables, and cigarette smoking status, salt use, and family history of hypertension or vascular disease were entered as co-variates. Activity score (β = 0.39, R = 0.16, P = 0.026) was indepen-

Table 3 Differences in clinical variables between hypotensives and normotensives in the male population

	Hypotensive	*Non-hypotensive*	*P*
No.	25	128	
Age	52.1 (10.1)	48.2 (8.5)	0.044
Height	179.9 (8.5)	178.4 (6.6)	0.32
Weight	84.7 (14.0)	84.3 (13.7)	0.90
Day systolic BP	121.4 (7.9)	133.5 (10.8)	0.001
Day diastolic BP	75.2 (6.3)	84.9 (7.8)	0.001
Night systolic BP	102.5 (6.4)	115.1 (12.4)	0.001
Night diastolic BP	60.5 (5.9)	69.3 (8.2)	0.001
Activity	5.1 (1.8)	4.6 (1.6)	0.14
Alcohol	13.5 (11.8)	17.0 (15.2)	0.20
Smoking (y/n)	4/21	23/105	0.54
Excess salt *(y/n)*	13/12	69/58	0.50
Plasma sodium	145.8 (4.8)	144.2 (9.7)	0.43
Creatinine	97.5 (11.0)	97.3 (13.6)	0.95
Family history of BP (y/n)	5/20	57/71	0.017
Family history of Vasc D *(y/n)*	16/9	54/74	0.05

BP, blood pressure; Vasc D, vascular disease. Figures in parentheses represent standard deviation of the mean.

Table4 Comparison of clinical variables between subjects who do or do not demonstrate hypotensive events

	Hypotensive events	No. hypotensive events	P
No.	120	124	
Age	47.4 (10.7)	47.2 (9.7)	0.88
Sex (m/f)	54/66	37/87	0.017
Height	172.5 (10.2)	174.6 (8.2)	0.09
Weight	73.5 (15.2)	80.5 (15.0)	0.001
Day systolic BP	120.5 (9.4)	133.7 (12.0)	0.001
Day diastolic BP	74.9 (7.0)	85.3 (7.8)	0.001
Night systolic BP	104.4 (9.5)	115.4 (12.6)	0.001
Night diastolic BP'	61.4 (6.3)	69.6 (8.5)	0.001
Activity	4.6 (1.3)	4.6 (1.6)	0.89
Alcohol (units/wk)	11.5 (11.2)	14.8 (14.8)	0.045
Smoking (y/n)	22/98	24/100	0.87
Salt use (y/n)	64/55	70/54	0.71
Sodium	144.3 (9.6)	143.4 (10.3)	0.49
Creatinine	88.3 (14.9)	93.4 (15.3)	0.009
Family history of BP	48/72	64/60	0.07
Family Hx of Vasc D	62/58	67/57	0.79

BP, blood pressure; Vasc D, vascular disease. Figures in parentheses represent standard deviation of the mean.

dently predictive of hypotensive means in the male cohort. A negative family history of vascular disease was also a significant predictor of the presence of hypotensive mean pressures (odds ratio (OR) = 1.7, 95% CI 1.01–2.9) in these subjects.

Hypotensive events

A total of 120 subjects (49.2%) exhibited hypotensive events. Female subjects were significantly more likely to show hypotensive events than males (59% *vs* 43%, $P = 0.01$, FET), despite having a lower threshold pressure for diagnosis of hypotension. This was due to a significant excess of hypotensive events in females compared with males during the day for systolic (35% vs 24%, $P = 0.046$, FET) and diastolic (44% *vs* 25%, $P = 0.003$, FET) pressures. The incidence of nocturnal hypotensive events did not differ between the sexes.

Differences in clinical variables between subjects who did or did not exhibit hypotensive events are shown in Table 4. Subjects exhibiting hypotensive episodes were significantly lighter and tended to be shorter; they also consumed significantly less alcohol. Total abstainers were not however significantly more frequently represented in the hypotensive group (22% vs 18%). Serum creatinine was significantly lower in the hypotensive cohort.

Discussion

Hypotension is a frequently diagnosed ailment in general practice, yet does not appear in textbooks as a disease state. Is it a forgotten illness?[9] A number of symptoms have been attributed to hypotension, from somatic symptoms of depression,[10] fatigue, anergia,[11] to an inability to perform prolonged physical work.[12] Some authors have speculated that symptoms of the chronic fatigue syndrome may be referable to low systemic arterial pressure.[13] Furthermore, a cross-sectional study has correlated a low systolic blood pressure with impaired mental and physical well-being,[14] and in a large population-based study, a low diastolic pressure was independently associated with depression and fatigue in older men, an association that was independent of age, recent weight loss, the presence of chronic disease, or antihypertensive or anti-depressant drug therapy.[15] Finally, a variety of studies have documented hypotension as an associated feature in subjects with fatigue,[3] anergia, and emotional lability.[16]

Hypotension therefore has been described as occurring in subjects with a consistent symptom complex and it has also been postulated that it may have a directly causal relationship to dysthymic syndromes.[17] As such, the phenomenon deserves further investigation, and this study provides a useful reference framework for further research, by defining a statistical lower limit of blood pressure on ambulatory monitoring. It also identifies some associated clinical features of low blood pressure states.

Is it valid to use a notional statistical cut-off value for the diagnosis of hypotension? The example is set here by hypertension, where treatment decisions are largely determined by exceeding a predetermined blood pressure value. In the case of hypertension, longitudinal studies have shown levels at which pathological sequelae are likely or unlikely. However, in the absence of similar data about the critical levels at which hypotension becomes symptomatic, and in the context of the consideration that (as with hypertension), not everyone beyond a certain value will inevitably suffer symptoms, the use of a statistically derived cut-off for normality is not unreasonable. The fifth percentile was used here, as it is likely that this level would delineate a significant extreme of physiology. The existing literature on symptoms of hypotension does identify clinic systolic and diastolic values at which symptoms develop — these vary from <75 mm Hg diastolic,[15] and ⩽115 mm Hg[10] and ⩽118 systolic[14] in males, 48.9 diastolic and ⩽109 mm Hg[10] and <100 mm Hg[18] systolic in females. Other work however has shown a linear association between symptoms and blood pressure falling from the middle of the blood pressure distribution.[11,16] The above values are based on clinic blood pressure estimation, so correlation with ambulatory blood pressure measurement is not straightforward.

Our results show that in females, weight is the single most important independent predictor of hypotensive blood pressure means and hypotensive events. This accords with the findings of other investigators.[10,11,19] Height was also lower in patients with hypotensive events, showing that these falls in pressure appear to be commoner in individuals with a characteristic body habitus; ie, those who are shorter and lighter than the general population. Our finding of a significantly lower creatinine in the hypotensive cohort would also accord with the hypothesis of hypotension occurring in subjects of a smaller build, and therefore a smaller muscle mass

The association of hypotension with morbidity has focused on symptoms of dizziness/tiredness, and psychiatric symptoms of mood disturbance. Mortality is not increased in these subjects, and actuarial analysis of survival rates shows those in the lowest blood pressure cohort (assuming no co-existing morbidity) have an increased survival.[20,21] However, this should not lead to complacency, when individuals remain distressed by symptoms attributable to low blood pressure. Our data would agree with the interpretation that hypotension is a condition associated with a low cardiovascular risk, in so far as those with hypotension were significantly less likely to display a positive family history of either hypertension or, in males, of vascular disease.

In conclusion, we have provided a working threshold of blood pressure values for the diagnosis and further study of hypotension. We have shown that hypotension identified using ambulatory blood pressure monitoring occurs frequently in the general population, and predominantly in females. It occurs in subjects with a characteristic physiognomy, raising the possibility that individuals who do suffer symptoms of hypotension might be able to reduce their symptoms by optimizing their body habitus.

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