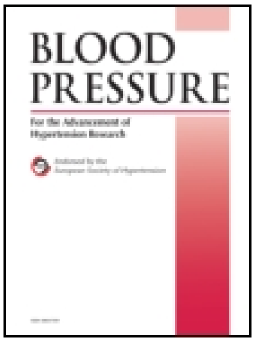

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ORIGINAL ARTICLE

Predictors of orthostatic hypotension in patients attending a transient ischaemic attack clinic: Database study

BEATRIZ DE LA IGLESIA[1], ALICE C. L. ONG[2], JOHN F. POTTER[2,3], ANTHONY K. METCALF[2] & PHYO KYAW MYINT[2,3,4]

[1]*School of Computing Sciences, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, Norfolk, UK,* [2]*Academic Department of Medicine for the Elderly, Norfolk and Norwich University Hospital, Norwich NR4 7UY, Norfolk, UK,* [3]*Norwich Medical School, University of East Anglia, Norwich Research Park, Norwich NR4 7TJ, Norfolk, UK, and* [4]*Clinical Gerontology Unit, Addenbrookes' Hospital, School of Clinical Medicine, University of Cambridge, Cambridge CB2 2QQ, Cambridgeshire, UK*

Abstract

Background. Orthostatic hypotension (OH) is common amongst the older population and is associated with morbidity and mortality. We sought to investigate predictors of OH to assist the clinician in identifying patients at risk. *Methods and results.* Database of 2696 patients attending a transient ischaemic attack (TIA) clinic between January 2006 and May 2009 was examined. Logistic regression models were constructed to determine clinical associates of OH. Demographics, co-morbidities, cardiovascular risk factors and medications were included in the multivariate models. Simple data mining models in the form of rule sets were developed for each component and they were assessed for predictive accuracy. The best models were validated on a smaller sample. Prevalence of OH was 22.3% in the TIA clinic population (50.6% men, mean 72 years; 49.4% women, mean 75 years). A significant postural drop in systolic blood pressure (BP) ($\geq$20 mmHg) was more prevalent than a significant diastolic BP drop ($\geq$10 mmHg). Isolated systolic hypertension was common (52.4%). Common factors predicting a significant systolic and diastolic BP fall were older age, previous TIA, being a current smoker, having diabetes and the use of beta-blockers. Both mean arterial and pulse pressure (MAP and PP) derived from supine BP were significantly associated with OH. *Conclusions.* OH should be assessed routinely in TIA clinics. MAP and PP may provide information on the predictability of OH.

Key Words: *blood pressure, epidemiology, orthostatic hypotension, predictors*

Introduction

Orthostatic hypotension (OH) is defined as a postural drop in systolic blood pressure (SBP) of $\geq$20 mmHg and/or diastolic blood pressure (DBP) of $\geq$10 mmHg from the supine to the standing position within 3 minutes of standing (1). OH is more prevalent in older adults being as high as 64% in some groups (2–5) with some evidence to suggest that symptomatic OH is more common in women (6) but the causes for this are not well understood (7).

OH has been linked to increased mortality (5), incidence of cardiovascular diseases (6,8–10) and increased risk of falls and fractures (11). Diastolic drop immediately after standing has been specifically shown to have significant association with coronary disease and vascular death (12), indicating that there may be important clinical implications of individual components of OH.

To date, several studies have identified factors that are associated with OH although the findings were not always consistent. These include male sex (in particular systolic drop) (9), hypertension (6) (in particular isolated systolic hypertension) (9,12), antihypertensive treatment (6), low body mass index (BMI) (6,9,12), cardiovascular disease and transient ischaemic attack (TIA) (12), current smoking (6) and high number of medications (9). Stroke and diabetes were significantly associated in some studies (6,9) but not in others (12).

Correspondence: Alice C.L. Ong, Academic Department of Medicine for the Elderly, Norfolk and Norwich University Hospital, Norwich NR4 7UY, Norfolk, UK. Tel: +44 (0) 1603 286286 Ext. 4011. Fax: +44 (0) 1603 286428. E-mail: alice.ong@nnuh.nhs.uk

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Blood pressure (BP) components can be estimated by the pulse pressure (PP) and the mean arterial pressure (MAP). The underlying physiological processes are affected by aging with changes in the pulse waveform and increasing PP (13,14). We were therefore interested in exploring whether these components of BP may provide information on the predictability of OH, and if so, how they would relate to either the systolic or diastolic postural components of OH. Secondly, cerebrovascular autoregulation (CA) protects against excessive oscillation in BP keeping the cerebral blood flow (CBF) constant against changes in MAP. However, it has been suggested (15) that beyond certain limits of CA, CBF is directly proportional to MAP and is "pressure passive". A sudden decrease in CBF may occur at the lower limits of CA causing some of the symptoms of OH. In patients with hypertension and OH, the CA mechanism may be different, with symptoms of OH being associated with a less drastic fall in BP. In addition, there is evidence that older people with hypertension can maintain CBF despite changes in brain perfusion pressures (16) and CA is maintained (17).

The aims of the study are (i) to examine which (if any) patient characteristics are associated with either or both a reduction in the SBP or DBP and (ii) also to investigate the association between other parameters of BP, PP and MAP, taken supine and OH on sitting or standing. Furthermore, the relationship between MAP, PP and OH was investigated taking into consideration the level of BP and thus the potential differences across the BP range. Finally, we set out to develop rules that can be applied in clinical practice to predict OH based on these parameters.

Materials and methods

Participants and measurements

The participants were drawn from a TIA clinic population who were referred for suspected TIA between 1 January 2006 and 15 May 2009. Height, weight and waist circumference were measured by trained clinical staff and BMI calculated and obesity was defined as a BMI $\geq$ 30 kg/m^2. Supine and standing BP were measured using a DINAMAP® (GE Health Care) automated machine. Supine BP was recorded after 5 min in the resting supine position, and standing BP was recorded after 3 min of standing with both feet on the floor, where patients were unable to stand the sitting BP after 3 min was used.

Smoking status and alcohol consumption were recorded as binary (yes/no) variables. The self-reported average alcohol consumption in units was also recorded in those who were current drinkers. The medications that were regularly prescribed and known to have BP lowering effect were recorded. For the purpose of this study, we used categorical binary variables (yes/no) and included: thiazide diuretics, ACEi/AIIRBs, beta-blockers, spironolactone, other diuretics, calcium-channel blockers and other medications. We also recorded the total number of medications taken.

There were 3152 records of attendance in the database during the above period. The first attendance data was used in this analysis for the 76 patients that had two attendances and the three patients who had three attendances during the study period. We excluded 456 patients who had missing values for any of the variables included in the analyses.

Analytical approach and rationale

Outcome measures. Three possible categories of OH, a reduction in BP of either $\geq$ 20 mmHg systolic or $\geq$ 10 mmHg diastolic or both, as per the consensus definition of OH (1) were used as outcomes.

Predictor variables. MEAN MAP AND PP. MAP is defined as the average arterial BP during a single cardiac cycle. MAP was estimated as MAP = DBP + 1/3 PP. PP was estimated as PP = SBP − DBP and represents BP variation. For this study purpose both MAP and PP were calculated using the BP measurements taken in the supine position.

HYPERTENSION. Participants were determined as hypertensive if they were previously diagnosed with hypertension from their medical records. We further classified them as presenting with high BP at clinic based on a one-off reading of evaluated BP at the clinic in the supine position. For this classification, we used the standard definition of hypertension for the systolic and diastolic components of BP as per the British Hypertension society (BHS) (18), the European Society of Hypertension (ESH) and World Health Organization/International Society of Hypertension (WHO/ISH). The limitation of this study is that the classification of patients for categorization of BP is based on a single clinic BP value as illustrated in Figure 1, as ambulatory BP monitoring data were not available. It should be noted that this was not for a clinical diagnosis of hypertension, which is carried out by ambulatory BP monitoring as per current guidelines, but for BP categorization. This categorization was used within the algorithms as a predictor instead of the numeric values for BP. If SBP and DBP fell into different categories, the higher value was taken for classification.

Data analysis

Initial univariate analysis was performed using *R* version 2.11.1 (open source software, http://www.r-project.org/) to explore the associations between all variables considered and OH. A Pearson chi-squared test with Yate's continuity correction for categorical

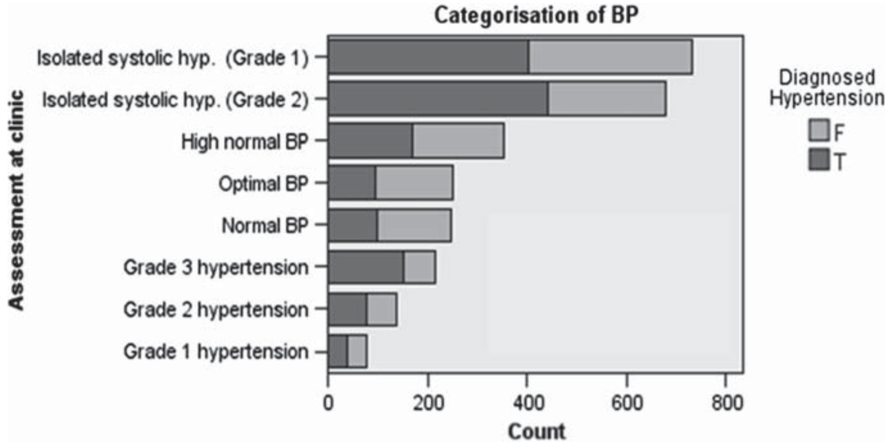

Figure 1. Distribution of blood pressure (BP) categories for the study subjects. The grey colour shows the proportion of participants in each category with diagnosed hypertension (i.e. T = True, F = False) prior to clinical assessment at the transient ischaemic attack (TIA) clinic.

and a non-parametric test, the Wilcoxon or Mann–Whitney *U* test, were used for continuous variables to test for independence. A value of $\alpha = 0.05$ is used to test for significant associations. Multivariate models were then constructed using SPSS PASW Modeler 14.0 (IBM Corporation, USA) which implements both statistical and data mining models. Logistic regression was used to build a multivariate model for the outcomes of either systolic or diastolic postural BP drop or both using the backward stepwise method. All variables were initially included in the models, except for the numeric BP values, which transformed into categories. The significance threshold used was $\alpha = 0.1$ as it was important to keep variables in the model if they could improve its predictive capabilities.

Additional models were also constructed using only one of MAP, PP and BP categories in the initial variable selection. MAP and PP are related by definition, MAP = DPB + 1/3PP, however, they only show a medium correlation (e.g. PP can be constant while MAP increases). The most accurate model containing either one or all of MAP, PP or BP categories were kept in the final model.

To establish how well a particular model predicts outcome, measures of accuracy, sensitivity, specificity and positive predictive power were calculated. Accuracy (Acc) represents the proportion of true results (both positive and negative: TP and TN) in the population. Sensitivity (Sen) represents the proportion of true positives and specificity (Spc) the proportion of true negatives. The positive predictive value (PPV) represents the proportion of true positives from those predicted as positive.

These measures were calculated for all models to guide the final model choices. The data mining algorithm C5.0 was used to create an alternative predictive model in the form of a rule set. Rule sets are derived from decision trees but are simplified models. However, with a rule set, no rule or more than one rule can be applied for any particular patient. If no rule applies, a default prediction is assigned to the patient. If multiple rules apply, each rule is weighted based on the confidence associated with that rule. Thus the final prediction is decided by combining all of the relatively weighted rules that apply to the patient.

In the second stage of the analysis, we validated the selected models for each outcome using a smaller sample of 288 patients who attended the same clinic between 18 May 2009 and 30 September 2009. The variables recorded were the same with the characteristics of the data being very similar to the construction sample except for a slightly higher percentage of females (55%).

Results

After excluding missing data for any of the variables included the analysis, a total of 2696 patients were included in the construction sample. The missing completeness of the data varies: BMI (9.4%), waist measurement (12.8%), SBP lying (7.5%), SBP standing (7.5%), DBP lying (7.5%) and DBP standing (7.4%). The missing data overlapped so the majority of patients who had one missing value for one variable, also had missing values for all other affected variables. Of those included, 953 patients (35.3%) had a diagnosis of TIA and 565 (21.0%) had a diagnosis of stroke, and the latter diagnosis may affect systemic BP. The remaining 1178 (43.8%) had a non-TIA diagnosis. A diagnosis of TIA was based on the presence of a transient neurological dysfunction due to focal brain or retinal ischaemia lasting not more than 24 h (but usually less than an hour), without evidence of acute infarction (19). The clinical characteristics of the construction sample are presented in Table I. An additional dataset (May–Sept 2009) containing 288 records with similar characteristics were available for the validation of the model.

The prevalences of systolic and diastolic postural drop are presented in Table II. Systolic drop was more prevalent (16.7% and 13.1%) than diastolic

Table I. Sex specific sample characteristics of the construction sample.

	Males	Females
	$n = 1364$ (50.6%)	$n = 1332$ (49.4%)
Age, years	72.0 (64.0–79.0)	75.0 (66.0–81.8)
Supine systolic BP, mmHg	151.0 (132.3–167.0)	154.0 (137.0–171.0)
Median systolic BP standing, mmHg (IQR)	147.0 (131.0–164.0)	149.0 (133.0–167.0)
Median diastolic BP supine, mmHg (IQR)	76.0 (68.0–85.0)	75.0 (66.0–84.0)
Mean diastolic BP standing, mmHg (IQR)	80.0 (72.0–89.0)	79.0 (70.0–88.0)
Mean body mass index, kg/m^2(IQR)	27.0 (24.0–30.0)	26.0 (23.0–30.0)
Waist measurement, cm (IQR)	98.0 (92.0–106.0)	87.0 (79.0–96.0)
Current smoker (%)	196 (14.4)	150 (11.3)
Ex-smoker (%)	789 (57.8)	464 (34.8)
Alcohol (%)	189 (13.9)	80 (6.0)
Previous conditions (%)		
Stroke	135 (9.9)	104 (7.8)
TIAs	138 (10.1)	127 (9.5)
Atrial fibrillation	165 (12.1)	138 (10.4)
Hypertension	718 (52.6)	761 (57.1)
Ischaemic heart disease	265 (19.4)	180 (13.5)
Other cardiac disease	59 (4.3)	49 (3.7)
Peripheral vascular disease	58 (4.3)	36 (2.7)
Obesity (≥ 30 kg/m^2)	353 (25.9)	340 (25.5)
Migraine	203(14.9)	361 (27.1)
Diabetes	203(14.9)	148 (11.1)
Known hyperlipidaemia	494 (36.2)	433 (32.5)
Medications (%)		
Thiazide	179 (13.1)	295 (22.2)
ACE/ARB	515 (37.8)	428 (32.1)
Beta-blockers	278 (20.4)	255 (19.1)
Diuretic	139 (10.2)	151 (11.3)
Calcium-channel blockers	226 (16.6)	241 (18.1)
Alpha-blocker	81 (5.9)	63 (4.7)
Spirolactone	1 (0.1)	1 (0.1)
Other therapy	61 (4.5)	84 (6.3)
Diagnosis		
Non-TIA	558 (40.9)	620 (46.6)
TIA	806 (59.1)	712 (53.4)

Data presented are median (interquartile range, IQR) for continuous variables and number (%) for categorical variables. BP, blood pressure; TIA, transient ischaemic attack; ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker.

drop (9.6% and 6.9%) in construction and validation samples, respectively. The prevalence of systolic drop was higher in females in both samples. Both sexes had similar prevalence of diastolic drop in the construction sample but males had higher prevalence in the smaller validation sample. When either systolic or diastolic drop was considered the prevalence of OH was higher as expected in females: 24.6% and 16.8% in females, and 20.1% and 14.5% in males in construction and validation samples, respectively. Less than 5% of the populations in both samples had both systolic and diastolic postural drop.

The prevalence of diagnosed hypertension in the construction sample was 55.1% (57.1% of females,

Table II. Prevalence (number (%)) of patients with postural hypotension in construction and validation datasets.

	Males	Females	All
Construction data			
Systolic drop (≥ 20 mmHg)	$n = 207$ (15.2)	$n = 244$ (18.3)	$n = 451$ (16.7)
Diastolic drop (≥ 10 mmHg)	125 (9.2)	133 (10.0)	258 (9.6)
Either (OH)	274 (20.1)	327 (24.6)	601 (22.3)
Both	58 (4.3)	50 (3.8)	108 (4.0)
Validation data			
Systolic drop (≥ 20 mmHg)	$n = 13$ (11.1)	$n = 21$ (14.7)	$n = 34$ (13.1)
Diastolic drop (≥ 10 mmHg)	10 (8.6)	8 (5.6)	18 (6.9)
Either (OH)	17 (14.5)	24 (16.8)	41 (15.8)
Both	6 (5.1)	5 (3.5)	11 (4.2)

OH, orthostatic hypotension.

52.6% males). Figure 1 shows the distribution of BP as assessed at the clinic based on single measurement, according to the BHS categorization. The majority of patients had isolated systolic hypertension either Grade 1 or 2. There was an increasing monotonic relationship between the degree of people with high BP at clinic assessment and the proportion of those already diagnosed as hypertensive. The presence of OH in the construction sample was mostly attributable to a drop of systolic BP with 57.1% of patients who presented with OH having an isolated drop of systolic BP. This is also in line with a majority of patients in our construction sample (52.4%) having isolated systolic hypertension. Of those presenting with isolated systolic drop, 65.9% had isolated systolic hypertension.

Higher values of MAP corresponded to the higher categories of hypertension (i.e. isolated systolic hypertension Grade 1 and 2 and hypertension Grade 1, 2 and 3 in this order). Higher values of PP corresponded also to increasing categories of hypertension although the relationship is less clear than for MAP.

Results of univariate models

Several factors were associated with falls in BP and are shown in Table III. Increasing categories of hypertension were also significantly associated with the presence of a postural fall in BP. Furthermore, when OH is considered per consensus definition (i.e. either systolic or diastolic postural drop in BP or both), the variables that are associated with OH were similar to those that were associated with the systolic drop.

Table III. Summary of univariate analysis.

BP drop	Associated variables	*p*-values
Systolic ($\geq$20 mmHg)	Previous TIA	<0.005
	Not obese	<0.005
	Diabetes	<0.005
	Higher PP	<0.001
	Higher MAP	<0.001
	Older age	<0.001
	Female sex	<0.05
	Ex-smoker	<0.05
	Lower BMI	<0.05
	Smaller waist size	<0.05
Diastolic ($\geq$10 mmHg)	Diabetes	<0.005
	Previous hypertension	<0.005
	Higher MAP	<0.001
	Older age	<0.001
	Previous TIA	<0.05
	Previous IHD	<0.05
	Atrial fibrillation	<0.05
	ACEi/AIIRBs	<0.05
	beta-blockers	<0.05
	Number of medications	<0.05

BP, blood pressure; TIA, transient ischaemic attack; PP, pulse pressure; MAP, mean arterial pressure; BMI, body mass index; IHD, ischaemic heart disease; ACEi, angiotensin-converting enzyme inhibitor; AIIRB, angiotensin II receptor blocker.

Results of multivariate models

The first part of Table IV shows the variables associated with systolic drop in the multivariate logistic regression model. Age, previous TIA, diabetes, lower BMI, current smoker and ex-smoker status, not taking a beta-blocker medication and elevated PP were considered. The odds ratios with their confidence intervals are presented. The model had an accuracy of 83.3% (87.3%), sensitivity 3.1% (2.9%), specificity 99.4% (100%) and PPV 51.9% (100%), respectively, on the construction (validation) dataset. It should be noted that although the sensitivity was low, the specificity is high, and the concept of predictive modelling is based on compromises between sensitivity and specificity, and is reflected in the overall accuracy. For the systolic drop, the initial regression model included both MAP and PP. A second model, presented here, was built using only PP, as it was actually more accurate than the original model. For diastolic drop, the initial model containing both MAP and PP was more accurate than a model containing only MAP or PP using both these variables was thus the model of choice.

The associates of diastolic drop were age, female sex, previous TIA, diabetes, current smoker status, elevated MAP, lower PP, the absence of a history of beta-blocker medication. Alcohol consumption >21 units per week lowered the odds of diastolic drop. The odds ratios with their confidence intervals for each of the associates are also presented in the second part of Table IV. The model had an accuracy of 91% (93.5%), sensitivity 15.5% (27.8%), specificity 99% (98.4%) and PPV 62.5% (55.6%), respectively, on the construction (validation) dataset.

According to the multivariate logistic regression, the associates of OH were age, female sex, previous stroke, previous TIA, lower BMI, diabetes, both current and ex-smoker status, and elevated MAP. The odd ratios with their confidence intervals for each of the associates are presented in the final part of Table III. The model had an accuracy of 79.8% (83.1%), sensitivity 19.1% (14.6%), specificity 99.4% (95.9%) and PPV 65.7% (40%), respectively, on the construction (validation) dataset.

Prediction rule derived from C5.0

Additional models using the C5.0 classifier were constructed and displayed similar levels of accuracy to the logistic regression models, while providing very simple conceptual description of the specific condition. The OH model is reported here and is used as an example due to space constraints. The C5.0 model for OH had an accuracy of 79.5% (85%), sensitivity 15.1% (7.3%), specificity 98% (99.5%) and PPV of 67.9% (75%) on construction (validation) sample. The model used only two variables: MAP and previous peripheral vascular

Table IV. Parameter estimates for logistic regression models.

	Odds ratio	95% CI		*B*	SE	*p*-value
Systolic drop model						
Intercept				− 4.266	0.641	0.000
Age	1.011	0.999	1.023	0.011	0.006	0.063
[TIAs = T]	1.686	1.233	2.306	0.523	0.160	0.001
BMI	0.962	0.938	0.986	−0.039	0.013	0.002
[Diabetes = T]	1.537	1.147	2.060	0.430	0.149	0.004
[Current smoker = T]	1.620	1.148	2.288	0.483	0.176	0.006
[Ex smoker = T]	1.396	1.108	1.759	0.333	0.118	0.005
[Beta-blocker – before = No]	1.288	0.979	1.695	0.253	0.140	0.070
Pulse pressure	1.030	1.024	1.036	0.029	0.003	0.000
Diastolic drop model						
Intercept				− 12.148	0.821	0.000
Age	1.052	1.036	1.069	0.051	0.008	0.000
[TIAs = T]	1.480	0.967	2.265	0.392	0.217	0.071
[Diabetes = T]	2.682	1.860	3.869	0.987	0.187	0.000
[Current smoker = T]	1.533	0.976	2.407	0.427	0.230	0.064
[Alcohol = T]	0.567	0.315	1.020	− 0.568	0.300	0.058
[Beta-blocker – before = No]	0.685	0.487	0.964	− 0.379	0.174	0.030
MAP	1.090	1.078	1.102	0.086	0.006	0.000
Pulse pressure	0.961	0.953	0.969	− 0.040	0.004	0.000
OH model						
Intercept				− 7.661	0.644	0.000
Age	1.026	1.015	1.036	0.025	0.005	0.000
[Sex – male = T]	0.755	0.615	0.927	− 0.281	0.105	0.007
[Previous stroke = T]	1.317	0.945	1.837	0.276	0.170	0.104
[TIAs = T]	1.580	1.167	2.140	0.458	0.155	0.003
BMI	0.976	0.954	0.998	− 0.024	0.011	0.035
[Diabetes = T]	1.811	1.377	2.382	0.594	0.140	0.000
[Current smoker = T]	1.514	1.091	2.101	0.414	0.167	0.013
[Ex smoker = T]	1.328	1.065	1.656	0.284	0.113	0.012
MAP	1.049	1.042	1.055	0.048	0.003	0.000

The reference category in each model is the FALSE category. CI, confidence interval; TIA, transient ischaemic attack; BMI, body mass index; MAP, mean arterial pressure; OH, orthostatic hypotension.

disease (Table V). The model describe patients with OH as those with a history of peripheral vascular disease and MAP > 111.0 mmHg or those with MAP > 132.7 mmHg.

Discussion

Our construction sample population had an OH prevalence of 20.1% in men and 24.6% in women. This provides novel prevalence data of OH in a general TIA clinic population where opportunistic screening may lead to appropriate intervention to prevent morbidity and mortality associated with it. Overall, this study is representative of a Caucasian Western Europe TIA clinic population and may not represent those in nursing homes or hospital inpatients, nor attendees at general medical outpatient clinics. As the mean ages of both men and women are over 70 years of age and a substantial proportion had a non-TIA diagnosis, it can be argued to be reasonably representative of older adults in the community. The slight difference in the prevalence in the validation population is likely to reflect the expected variability (20–24). The high prevalence of OH in our relatively young population is significant because OH is associated with increased mortality in periods of over a decade, even with younger mean age of 57 years (HR = 2.4, 95% CI 2.1–2.8), and even if cardiovascular disease is taken into account (HR = 2.0, 95% CI 1.6–2.7) (3).

In the majority of cases within our population, the presence of OH was confirmed with a significant SBP fall. This is clinically important as an isolated postural fall in SBP of more than 20 mmHg is associated with a significantly higher age-adjusted rate of mortality (10.2 per 100) compared with those with a fall of < 20 mmHg (6.56–7.7 per 100) (25). Postural falls in DBP of 10 mmHg or more is also clinically significant as it has been associated with a fivefold increase in the rate of myocardial infarction (MI) in those with higher resting DBP after age adjustment. For example where the sitting DBP was ≥ 90 mmHg, the age-adjusted rate was 25.2 per 1000 man-year, whereas if the postural fall in DBP was 9 mmHg or less, this fell to 5.5 (26).

An increase in cardiovascular disease risk has been shown to be related to a higher PP (27,28), particularly in young men (18). We found that both systolic and diastolic drop independently or when combined as per the definition of OH showed a strong association with supine MAP and PP.

Table V. C5.0 Rule set containing two rules for orthostatic hypotension (OH) True and two rules for OH False categories.

Rules for OH = True – contains 2 rule(s)
if Peripheral vascular disease = T and MAP > 111 then T (22 instances; 77.27%)
if MAP > 132.7 then T (116 instances; 67.2%)
Rules for OH = False – contains 2 rule(s)
if MAP < = 111 then F (2021instances; 83.7%)
if Peripheral vascular disease = F and MAP < = 132.7 then F (2490 instances; 79.9%)
Default: False

The reference category is the false category. The figures in parenthesis show the number of instances that each rule applies to and the confidence of the rule. Rules are not mutually exclusive. This is only one example. MAP, mean arterial pressure.

Univariate analysis confirmed the increasing presence of OH with increasing hypertension (29) but also showed that systolic and diastolic postural falls in BP have different associates suggesting that they may be different clinical entities. However, in the multivariate analysis they were both associated with increasing age, a positive history of TIA or diabetes, a current smoking status, the absence of beta-blockers amongst current medication and PP. Systolic drop was additionally associated with a low BMI and being an ex-smoker, whereas a diastolic postural drop was associated with alcohol and MAP. For OH additional associates were female sex and previous stroke. MAP and ex-smoker also featured in the regression model for OH whereas PP did not.

OH was shown to increase with age in our and other studies (6,29–31). Our study also found that OH (using either DBP or SBP criteria) was associated with diabetes and smoking status as well as anti-hypertensive treatment. Studies have shown an association between diabetes and hypertension and the presence of OH amongst those with diabetes (32). Another study of patients with diabetes found that those with OH had higher level of smoking (in pack years) recorded (33). Although Kamaruzzaman et al. (31) also showed that OH was associated with the number of anti-hypertensives, they did not look at individual drugs as we attempted to do here.

In addition to identifying the determinants of OH and its components in a TIA clinic population, we wish to assist clinicians in predicting those patients who were at higher risk of having OH and therefore at increased risk of morbidity and mortality. The predictive models for systolic and diastolic drop and OH suffered from low sensitivity and hence would not be able to identify correctly many of the positive cases. However, the models had acceptable PPV, hence among those predicted to have the condition a reasonable proportion (over 40%) in all cases were found to have the condition. When compared with the underlying prevalence in the population (under 25% in all groups) the models may help to identify patients at increased risk of OH for whom appropriate management may bring measurable clinical benefits such as reduced cardiovascular events and falls.

It was also possible to create a simple rule set for predicting OH by using MAP and a history of peripheral vascular disease. Such simple representation of a predictive risk model could be incorporated very easily in a preliminary assessment of elderly patients so that those that appear at high risk of OH can be diagnosed and managed effectively. This may include discontinuation or commencement of medication such as fludrocortisone (33) and midodrine (34), sleeping with the head up (35) and the use of physical manoeuvres (36) when appropriate.

Our study is limited by the fact it was a retrospective observational study based on a database, which meant that the BP measurements used were based on a single clinic attendance in most cases. This is not ideal, as some measurements could be artificially high, with patients being categorized as having hypertension for the purposes of BP categorization in the algorithm when they may have a normal BP. However, it is likely that when there is a significant drop in BP, this relative drop would remain present. Furthermore it should be highlighted that there are other classifications of hypertension other than that used here, e.g. the American Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, which has a simplified classification (37) containing only four categories. The validation dataset used was insufficient to provide a good independent test, and needs further validation in other populations.

Conclusions

OH most often appears as a fall in SBP and is common in older patients in both TIA and non-TIA patients. SBP and DBP postural falls are associated with common but various factors such as hypertension, age and smoking status. The prevalence of OH in this TIA clinic population is about 20% highlight the fact that lying/standing BP assessment should be carried out routinely in TIA clinics. By proactively identifying OH, clinicians may be able to reduce the morbidity and mortality associated with OH. We have also shown that both MAP and PP are highly significant factors and could be useful in creating new predictive models to assist the clinician in predicting OH in patients. This may be particularly useful where clinicians are unable to carry out a lying and standing BP due to time constraints in a busy clinic, or where patients are physically unable to do so. Alternative models from the data mining domain not often used in medicine such as the rule set presented can have equal predictive properties as the regression models but are much easier to action in a clinical setting and so should be considered a complementary approach in future clinical research.

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