Elevated Diastolic, But Not Systolic, Blood Pressure Measured in the Emergency Department Predicts Future Development of Hypertension in Normotensive Individuals

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Elevated blood pressure (BP) is reported in many individuals without hypertension presenting to the emergency department (ED). Whether this condition represents a transient state or is predictive for the development of future hypertension is unknown. This observational prospective study investigated patients admitted to an ED without a diagnosis of hypertension in whom BP values were ≥140/90 mm Hg. The primary outcome was development of hypertension during follow-up. Overall, 195 patients were recruited and at the end of follow-up (average 30.14±15.96 months), 142 patients were diagnosed with hypertension (73%). The mean age (50±12.25 vs 48.31±13.9, *P*=.419) and sex distribution (78 men/64 women vs 24 men/20 women, respectively; *P*=.148) were similar in both groups. There were significant differences in systolic and diastolic BP between those who developed hypertension on follow-up and those who did not (177.6 mm Hg±22.6/106.1 mm Hg±16.9 vs 168.6 mm Hg±18/95.2 mm Hg±12.2; *P*=.011 for systolic BP, *P*<.001 for diastolic BP). In multivariate analysis the only significant predictive factor for the development of hypertension was diastolic hypertension recorded in the ED (*P*=.03). Elevated diastolic, but not systolic, BP among patients presenting to the ED is associated with future development of hypertension in previously normotensive individuals. *J Clin Hypertens (Greenwich).* 2015;17:359–363.

Admission to the emergency department (ED) is certainly a stressful situation. Many patients without a diagnosis of hypertension admitted to the ED with various etiologies have blood pressure (BP) >140/90 mm Hg.[1] Possible causes for this increment in BP in the ED setting is pain and anxiety. On the other hand, other patients with the same pain and anxiety level do not have increased BP. This increase of BP in the ED setting may be viewed as a form of white-coat hypertension, an entity associated with the future development of hypertension.[2–6] Yet, it is unclear whether patients with high BP values recorded in the ED setting are also at increased risk for the development of future hypertension. We conducted a prospective study in which patients without a history of hypertension in whom BP measurements recorded in the ED were ≥140/90 mm Hg were followed for the development of hypertension.

METHODS

Study Population

This was an observational prospective study in which patients aged 18 to 80 years admitted to the ED of Rabin Medical Center were evaluated. Rabin Medical Center is a tertiary center located in central Israel and its ED is the third largest in Israel, with more than 150,000 annual visits. The study population included patients without a previous diagnosis of hypertension and with a discharge diagnosis of elevated BP in the years 2009 to 2010. Hypertension was defined by a persistent record of elevated office BP values ≥140/90 mm Hg, an average BP >135/85 mm Hg on ambulatory BP monitoring, or treatment with antihypertensive medications. Patients were followed prospectively until May 2014. The study was approved by the Rabin Medical Center institutional review board.

Inclusion and Exclusion Criteria

Patients were included if they were aged 18 to 80 years without a prior diagnosis of hypertension in which BP recorded in the ED was ≥140/90 mm Hg. Patients with a prior diagnosis of primary or secondary hypertension were excluded from the study. A history of hypertension was excluded when "hypertension" was not listed as one of the chronic medical problems in the patient's medical file, when persistent office BP values ≥140/90 mm Hg or an average BP >135/85 mm Hg on ambulatory BP monitoring were not recorded, and when antihypertensive medications were not dispensed prior to the ED visit.

BP Measurement and Data Collection

BP measurement was performed by a nurse or a physician with the patient in a sitting or supine position following at least 5 minutes of rest. When BP was ≥140 mm Hg systolic or 90 mm Hg diastolic, a second

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BP measurement was taken to confirm the values at least 5 minutes following the initial measurement. BP was measured in a single arm, which was arbitrarily chosen by the nurse or physician, unless the patient requested the BP to be measured in a certain arm because of a history of higher BP values in that arm. BP measurements were taken with a standard sphygmomanometer (Vital Signs Monitor 52 NTP model; Welch Allyn Protocol Inc, Beaverton, OR) calibrated according to the manufacturer's recommendations. Standard or large cuffs were used as appropriate.

Medical history and patients' characteristics were retrieved from the patients' computerized medical records and included age, sex, body mass index, comorbidities (diabetes mellitus, dyslipidemia, anxiety, hyperthyroidism, atrial fibrillation, ischemic heart disease, and cerebrovascular disease), vital signs in the ED, the major complaint, and score on the visual analog scale for pain (VAS).[7] Laboratory parameters included serum creatinine, potassium, sodium, and troponin T values. The Modification of Diet in Renal Disease (MDRD) formula[8] was used to calculate glomerular filtration rate (GFR).

Follow-Up

Primary outcome was future development of hypertension. Information on the development of hypertension was available either from the hospital records or via the community registry. We contacted patients or treating physicians via telephone if the chart information was incomplete. Patients were classified as hypertensive if they had persistent office BP values >140/90 mm Hg, had an average BP >135/85 mm Hg on ambulatory BP monitoring, or were treated with antihypertensive medications during the follow-up period.

Statistical Analysis

Statistical analysis was performed using SAS software (version 9.4; SAS Institute Inc, Cary, NC). Continuous variables are presented as mean±standard deviation and categorical variables were presented as number (percentage). Student *t* test was used to compare the value of continuous variables between study groups, and chi-square was used to compare the value of categorical variables between study groups. The magnitude of association between continuous variables was assessed by Pearson correlation. A general linear model was fitted to assess multivariate effects of predictors for the development of hypertension.

RESULTS

Baseline characteristics of patients who developed hypertension, patients who did not develop hypertension, and the entire study group are presented in Table I. The clinical and laboratory characteristics during the ED visit are presented in Table II. Overall, 195 patients were recruited to the study and at the end of the follow-up 142 patients were diagnosed with hypertension (73%). Average follow-up time of the entire cohort was 30.14±15.96 months and was similar in those who developed hypertension and those who did not (29.58±15.97 and 31.10±15.80, *P*=.561). The

TABLE I. Baseline Characteristics of the Study Cohort

	Hypertension Group	Non-Hypertension Group	Entire Cohort	*P* Value
No. (%)	142 (73)	53 (27)	195 (100)	
Age	50±12.25	48.31±13.9	49.71±12.73	.419
Male/female, No.	78/64	24/29	102/93	.148
Physician referral, No. (%)				
Hypertension	48 (33.8)	15 (28.3)	63 (32.3)	.9
Other reasons	45 (31.6)	18 (34)	63 (32.3)	
No referral	49 (34.5)	20 (37.7)	69 (35.3)	
Follow-up, mo	29.58±15.97	31.10±15.80	30.14±15.96	.561
Major complaint, No. (%)				
Headache	48 (33.8)	15 (28.3)	63 (32.3)	.56
Asymptomatic[a]	21 (14.7)	4 (7.5)	25 (12.8)	.16
Weakness	6 (4.2)	3 (5.66)	9 (4.6)	.63
Chest pain	10 (7)	7 (13.2)	17 (8.7)	.149
Palpitations	8 (5.6)	3 (5.66)	11 (5.6)	.94
Dizziness	10 (7)	4 (7.5)	14 (7.1)	.85
Comorbidities, No. (%)				
Diabetes mellitus	16 (11.2)	5 (9.4)	21 (10.7)	.773
Dyslipidemia	59 (41.5)	17 (32)	77 (39.4)	.3
Obesity	43 (30.2)	8 (15)	51 (26.1)	.043
Hypothyroidism	7 (5)	5 (9.4)	12 (6.1)	.2
Anxiety	0	3 (5.6)	3 (1.5)	.67

Values are expressed as mean±standard deviation unless otherwise indicated. [a]Asymptomatic patients referred by their physician for high blood pressure.

TABLE II. Clinical and Laboratory Data of the Study Cohort

	Hypertension Group	Non-Hypertension Group	Entire Cohort	*P* Value
Patients, No. (%)	142 (73)	53 (27)	195 (100)	
Systolic value	177.64±22.60	168.59±17.98	175.19±21.79	.011
Diastolic value	106.13±16.94	95.2±12.19	103.16±16.46	<.001
Pulse pressure	71.51±17.8	73.39±20.5	72.03±19.3	.549
Heart rate	86.06±16.24	90.04±18.21	87.14±16.91	.149
VAS score	2.34±3.04	3.55±3.02	2.74±3.12	.04
Creatinine, mg/dL	0.79±0.2	0.73±0.18	0. 0.77±0.2	.044
Urea	30.94±8.58	29.65±8.59	30.6±8.56	.356
EGFR (MDRD), mg/dL	97.48±24.75	105.63±29.02	99.64±25.99	.058
Sodium, mg/dL	35±2.54	138.33±2.60	138.36±2.55	.964
Potassium, mg/dL	4.14±0.38	4.22±0.38	4.17±0.39	.162
Troponin, mg/dL[a]	0.02±0.04	0.01	0.02±0.04	.101

Abbreviations: MAP, mean arterial pressure; MDRD, Modification of Diet in Renal Disease; VAS, visual analog scale. [a]Troponin level after excluding patients with estimated glomerular filtration rate (eGFR) <60 mg/dL. Values are expressed as mean±standard deviation unless otherwise indicated.

mean age (50±12.25 vs 48.31±13.9, *P*=.419) and sex distribution (78 men/64 women vs 24 men/20 women, respectively, *P*=.148) were also similar in both groups. Patients were referred to the ED by their primary care physician because of elevated BP (63 patients [32.3% of the cohort]), because of another reason (63 patients [32.3% of the cohort]), or attended the ED without being referred by a physician (69 patients [35.3% of the cohort]). The most common presenting symptom in the ED was headache (63 patients [32.3%]). Other common complaints in decreasing prevalence were chest pain (17 [8.7%]), dizziness (14 [7.1%]), palpitations (11 [5.6%]), and weakness (9 [4.6%]). A total of 25 patients (12.8% of the cohort) were asymptomatic at presentation. Presence of symptoms was not associated with the future development of hypertension.

Prevalence of comorbidities (diabetes mellitus, dyslipidemia, hypothyroidism, anxiety) in the two groups was similar except for overweight, defined by a body mass index >25 kg/m^2, which was significantly more prevalent in those who developed hypertension (43 [30.2%] vs 8 [15%], *P*=.043).

There were significant differences in the mean±standard deviation of systolic and diastolic BP between those who developed hypertension on follow-up and those who did not (177.6 mm Hg±22.6/106.1 mm Hg±16.9 vs 168.6 mm Hg±18/95.2 mm Hg±12.2, respectively; *P*=.011 for systolic BP and *P*<.001 for diastolic BP). The VAS score for pain estimation in the ED was higher in those who did not develop hypertension compared with those who did (3.55±3.02 vs 2.34±3.04, respectively; *P*=.04). Higher creatinine level were observed in those who developed future hypertension compared with those who did not (0.79±0.2 vs 0.73±0.18, respectively; *P*=.044) but the mean±standard deviation eGFR values were similar between the two groups (97.48±24.75 vs 105.63±29.02, respectively; *P*=.058). Troponin T values were similar between the two groups, as were all other laboratory variables evaluated (Table II).

In patients who developed hypertension during the follow-up period, the most common prescribed drug was an angiotensin-converting drug inhibitor (61 patients [43%]). Other drugs used in descending order were β-blockers (52 patients [36.62%]), calcium antagonists (49 patients [34.51%]), angiotensin receptor blockers (37 patients [26%]), and diuretics (32 patients [22.5%]). Twelve patients (8.45%) diagnosed with hypertension received no medical treatment. The number of drugs taken by the patients was 1.64±0.89.

In multivariate analysis for age, VAS score, creatinine, obesity, and systolic and diastolic hypertension, the only significant predictive factor for the development of future hypertension was diastolic hypertension (*P*=.03).

DISCUSSION

Hypertension is the most common condition seen in primary care, affecting more than 30% of the population,[9] and is associated with significant morbidity and mortality.[10] Early diagnosis of hypertension has been shown to reduce long-term hypertension-related complications in outpatient settings.[11] Conditions such as white-coat hypertension and prehypertension (defined as systolic BP >120 mm Hg to 139 mm Hg or diastolic BP 80 mm Hg to 89 mm Hg) have been strongly linked with the development of hypertension in numerous studies,[12–14] but investigations evaluating the association between elevated BP in ED patients without a diagnosis of hypertension and the future development of hypertension are lacking. This may be the result of the attribution of elevated BP in the ED to anxiety associated with pain or the stress of visiting an ED. Yet, several studies have confirmed that the majority of cases of newly recorded high BP found in patients in the ED are indicative of prehypertension or hypertension.[15–20] This is the first prospective study in which the association between elevated BP values in previously normotensive individuals and the development of future hypertension was evaluated.

A high percentage (73%) of the patients in this cohort developed future hypertension. Karras and colleagues[21] conducted a similar study in which they enrolled 1396 patients with various complaints with elevated BP in the ED, of which 25% were not aware of their elevated BP. Julliard and colleagues[22] enrolled 695 patients with high BP in the ED without a previous diagnosis of hypertension, of which 197 were considered to be "patients with a pattern of BP readings suggestive of hypertension." Although the rate of follow-up in these patients was rather low and hypertension was reported to develop in only 29% of the cohort, the authors did observe that patients with a pattern of BP readings suggestive of hypertension were significantly older and more likely to be men, associations that were not observed in our study.

Factors in the ED that were found to be predictive of future hypertension in our study were systolic (P=.01) and diastolic BP values recorded in the ED (P<.01). Creatinine was also found to be predictive of future hypertension (P=.044), but this was not reproducible for eGFR calculated by the MDRD formula, which is considered a more precise method for evaluating kidney function.

The only significant predictor for the development of future hypertension that persisted on multivariate analysis was diastolic BP recorded in the ED. Previous studies have noted an association between diastolic BP values and the white-coat effect, but a similar association was also noted for systolic BP and this was not evident in our study.[23,24] Although patients presenting to the ED with headaches were reported to have a high prevalence of headaches,[25] we did not identify any studies in which diastolic BP recorded in the ED was predictive of future hypertension. It is possible that those with elevation of both systolic and diastolic BPs represent those with the greater potential for the development of future hypertension and these individuals should be monitored for closer follow-up. Because previous studies reported an extremely low rate of follow-up in the primary care setting of those with elevated BP values recorded in the ED, it would probably be useful to limit follow-up of high BP to those with both systolic and diastolic BP elevation. Those with an isolated elevation of systolic BP and particularly those with tachycardia probably represent those with a high sympathetic drive and an exaggerated response to stress or pain in which the risk for the development of future hypertension is probably smaller than those with elevated diastolic BP, which may be less dependent on sympathetic drive. Support for this hypothesis comes from the negative association between the VAS score and future development of hypertension. Again, patients with high VAS scores probably have high BP in the ED caused by a high sympathetic drive, whereas those with a low VAS score and elevated BP probably represent those with true hypertension. In a study by Fleming and colleagues,[16] patients who presented with a VAS 10/10 pain score had a mean BP 8.4 mm Hg higher than those with lower pain perception. In their study, 62% of patients presenting with VAS >5/10 still had hypertension on a repeat BP measurement following reduction of the painful stimulus, but no long-term follow-up was performed.

Headache (63 patients [32.3%]), chest pain (17 [8.7%]), dizziness (14 [7.1%]), palpitations (11 [5.6%]), and weakness (9 [4.6%]) were the most common presentations in the ED. These symptoms are commonly referred to as "hypertension-associated symptoms." Other studies concerning hypertension in the ED also reported similar symptoms.[25,26]

STUDY LIMITATIONS

Our study is not without limitations. First, it was an observational study and follow-up was not performed from the ED visit. Second, because we did not have BP measurements prior to the ED visit, we based our assumption on the patients' medical charts in which there was no diagnosis of hypertension and no antihypertensive medications were dispensed. Although some of these patients may have had undiagnosed hypertension, we believe that this represents a "real-life" situation in which the lack of baseline hypertension is assumed based on the parameters used in our study. Third, although we performed two initial BP measurements in those with elevated BP recordings in the ED and used the second recording, BP was not remeasured during the ED visit. A repeat BP measurement may have reduced the number of patients with elevated BP in the ED. Yet, since under most circumstances BP is not remeasured in the ED, we believe that this study represents the actual clinical scenario of elevated BP in the ED. Another limitation is that incomplete information required telephone contact with several patients, which may have led to a bias toward a higher prevalence of future hypertension in the cohort. However, because we did not have complete information in fewer than five individuals and because we were able to get complete information from all individuals, we believe that this limitation was not associated with any significant bias.

CONCLUSIONS

Elevation of both systolic and diastolic BP values in the ED is associated with future development of hypertension in previously normotensive individuals. Future development of hypertension is highest in those with elevated diastolic BP and in those with low VAS scores, and these individuals should probably receive the most intense follow-up.

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doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

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