Medicine®

OBSERVATIONAL STUDY

OPEN

Impact of Admission Systolic Blood Pressure and Antecedent Hypertension on Short-Term Outcomes After ST-Segment Elevation Myocardial Infarction

Strobe-Compliant Article

Wenfang Ma, MD, Yan Liang, PhD, Jun Zhu, MD, Yanmin Yang, PhD, Huiqiong Tan, MD, Litian Yu, PhD, Xin Gao, PhD, Guangxun Feng, MD, and Jiandong Li, MD

Abstract: We evaluated the combined effect of admission systolic blood pressure (SBP) and antecedent hypertension on short-term outcomes in patients with ST-segment elevation myocardial infarction (STEMI). Data were derived from a multicenter survey of 7303 consecutive patients with STEMI. Patients were divided into 4 groups according to different blood pressure status: high SBP without hypertension, high SBP with hypertension, low SBP without hypertension, and low SBP with hypertension. The primary endpoints were 7 and 30-day all-cause mortality. The prevalence of hypertension was 40.7%, and the best cutoff of admission SBP for predicting 30-day mortality was 108 mmHg by receiver-operating characteristic curve. Patients with hypertension were older, more often female, also had longer onset-to-admission time, more comorbidities, and higher Killip class. Patients with both low SBP ($\leq$108 mmHg) and hypertension group had significantly higher 7 and 30-day mortality than those in other groups (all $P < 0.001$). After multivariate adjustment, low SBP with hypertension group was still an independent risk factor for predicting 7-day mortality (hazard ratios [HR] 1.86, 95% confidence interval [CI] 1.41–2.46; $P < 0.001$) and 30-day mortality (HR 1.88, 95% CI 1.46–2.43; $P < 0.001$). In patients with SBP $>$ 108 mmHg, a history of hypertension could increase the risk of 30-day mortality by 27% (HR 1.00 vs 1.27, $P = 0.012$), while in patients with SBP $\leq$ 108 mmHg, this increased risk reached to 37% (HR 1.51 vs 1.88, $P < 0.001$). In conclusion, low admission SBP was the relatively dominant contributor for predicting 7 and 30-day all-cause mortality, and a concurrent antecedent hypertension increased the corresponding risk of mortality.

(*Medicine* 94(34):e1446)

Abbreviations: ACS = acute coronary syndrome, AMI = acute myocardial infarction, CI = confidence interval, HR = hazard ratios, SBP = systolic blood pressure, STEMI = ST-segment elevation myocardial infarction, TIMI = thrombolysis in myocardial infarction.

INTRODUCTION

Hypertension is one of the main factors leading to atherosclerosis and the development of vulnerable plaques whose instability and rupture are responsible for acute coronary syndrome (ACS). In patients with acute myocardial infarction (AMI), the prevalence of antecedent hypertension varies from 46.0% to 63.4%.[1–4] Until recently, many studies evaluated the prognostic significance of a previous history of hypertension in patients presented with AMI and came to inconsistent results.[5–12] Moreover, many established multivariable risk score models, such as the thrombolysis in myocardial infarction (TIMI) risk score, for initial assessment of AMI on admission have not found hypertension, defined as a ''yes or no'' categorical variable, to be independently associated with short- or long-term mortality.[13–16] A recent high volume study by Erne et al[17] even came to results that preexisting hypertension was associated with an improved in-hospital prognosis in ACS patients. To address the critical discordance, more studies are needed to assess the impact of hypertension in those patients. Indeed, lower admission systolic blood pressure (SBP) more often emerges as risk predictor of poor outcomes in contemporary evaluations, in which different levels of low SBP are given corresponding high points for predicting mortality after myocardial infarction.[13,16] Some studies[18–21] have evaluated the effect of admission SBP on outcomes of high-risk ACS, while few data are available about the combined effect of admission SBP and hypertension. So, we conduct this study to explore the impact of admission SBP and antecedent hypertension on short-term outcomes in patients with ST-segment elevation myocardial infarction (STEMI).

METHODS

Study Population

We retrospectively evaluated 7303 consecutive patients presenting with acute STEMI within 12 hours after the onset of symptoms in 247 Chinese hospitals between 2001 and 2004. The diagnosis of STEMI was followed the universal definition of myocardial infarction.[22] In detail contents included chest pain or equivalent symptoms in combination with persistent ST-segment elevation more than 0.1 mV in at least 2 contiguous extremity leads or 0.2 mV in at least 2 contiguous precordial leads, or new onset of left bundle branch block, and a positive biomarker troponin I or creatine kinase-MB indicating myocardial necrosis.

Editor: Imo Hoefer.
Received: June 6, 2015; revised: July 9, 2015; accepted: July 23, 2015.
From the State Key Laboratory of Cardiovascular Disease, Emergency and Critical Care Center, National Center for Cardiovascular Diseases, Fuwai Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, People's Republic of China.
Correspondence: Yan Liang, State Key Laboratory of Cardiovascular Disease, Emergency and Critical Care Center, National Center for Cardiovascular Diseases, Fuwai Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, People's Republic of China (e-mail: fwliangyan@sina.cn).
Supplemental Digital Content is available for this article.
The authors have no funding and conflicts of interest to disclose.
Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.
This is an open access article distributed under the Creative Commons Attribution-NoDerivatives License 4.0, which allows for redistribution, commercial and non-commercial, as long as it is passed along unchanged and in whole, with credit to the author.
ISSN: 0025-7974
DOI: 10.1097/MD.0000000000001446

Exclusion criteria included any history of hemorrhagic stroke within 12 months, gastrointestinal bleeding or active peptic ulcer within 3 months, major surgery or trauma within 2 weeks, coagulation disorders associated with bleeding tendency, and renal dysfunction with creatinine >2.0 mg/dL or 175 μmol/L, pregnancy, life expectancy of less than 1 month. After admission, patients received reperfusion therapy with thrombolysis or percutaneous coronary intervention according to local clinical circumstances. Subsequent medication treatments were as far as possible consistent with the guidelines back then. Study protocol was approved by the local ethics committee and the institutional review board of Fuwai Hospital. All participants provided written informed consent.

Data Collection

Data collected at baseline included gender, age, weight, and previously known medical history (myocardial infarction, diabetes mellitus, hypertension, heart failure, and stroke). Particularly, patients who reported a diagnosis of hypertension or the use of antihypertensive medications as per the recommendation of a physician antecedent to their myocardial infarction were considered to have hypertension. A 12-lead electrocardiogram was carried out in each patient just after hospital admission. Initial heart rate and blood pressure were measured accurately in the supine position. For blood pressure measurement, 2 separate readings were taken and averaged. Killip class was evaluated by physical examination and all the subsequent medication treatments were obtained from the medical records. The follow-up time was 30 days. Visit times were scheduled at the 7th and 30th day after hospitalization, during which predefined clinical events with the occurrence time were recorded. All these data were collected prospectively by the local physicians using unified case report forms and were sent to the central administrative office of the study located at the Fuwai Hospital, Beijing.

Clinical Endpoints

The primary endpoints were 7- and 30-day all-cause mortality. The secondary endpoints included reinfarction (recurrent ischemic chest pain with new electrocardiographic changes including ST reelevation or depression or new Q waves, and with increase in enzyme level to at least twice the upper limit of normal or, if enzymes were already elevated, levels >50% of the lowest enzyme level), stroke (a new onset of neurological deficits that persisted for >24 hours and confirmed by computed tomographic scans or magnetic resonance imaging), cardiac arrest (successful resuscitation from either ventricular fibrillation, sustained ventricular tachycardia, or asystole), and cardiac shock (persistent SBP < 90 mmHg, unresponsiveness to fluid administration, and requirement for intravenous inotropic therapy or insertion of an intraaortic balloon pump).

Statistical Analysis

All statistical analyses were performed using SPSS version 19.0 (SPSS Inc., Chicago, IL) and SAS version 9.1 (SAS Institute, Cary, NC). The study population was prior stratified into 4 groups according to the admission SBP and history of hypertension. A propensity score matching was used to adjust for differences in baseline characteristics between groups. In detail the optimal cut-off value of SBP for predicting 30-day all-cause mortality was based on optimizing the sum of sensitivity and specificity by receiver-operating characteristic curve analysis. Then between-group comparisons of the baseline characteristics were compared using χ^2 test or Fisher exact test for categorical variables and one-way analysis of variance or the Kruskal–Wallis test for continuous variables as appropriate. Short-term outcomes among the 4 groups were compared using χ^2 test or Fisher exact test. Cumulative survival curve for 30-day all-cause mortality was constructed using the Kaplan–Meier method, with differences assessed with the log-rank test. Multivariate Cox proportional hazard regression models (backward LR method) were performed to identify predictors of 7- and 30-day all-cause mortality. Besides our newly defined blood pressure groups, other covariates entered into the Cox models included gender, age, weight, heart rate, diastolic blood pressure, onset-to-admission time, previous medical histories (myocardial infarction, diabetes mellitus, heart failure, and stroke), Killip class, myocardial infarction location on electrocardiogram, reperfusion strategies, and other main medications. The adjusted hazard ratios (HRs) with their respective 95% confidence intervals (CIs) for each variable were calculated. All statistical tests were 2-tailed, and a P value <0.05 was considered statistically significant.

RESULTS

In our study population, 2969 were hypertensive, accounting for a 40.7% prevalence of antecedent hypertension state. The best cutoff of admission SBP for predicting 30-day all-cause mortality was 108 mmHg by receiver-operating characteristic curve. With this threshold, 5691 patients had a value of SBP > 108 mmHg, in which 2527 (44.4%) patients reported antecedent hypertension. Although the remainder 1612 patients had a value of SBP ≤ 108 mmHg, in which 442 (27.4%) patients reported hypertension.

Baseline Characteristics

Table 1 shows the baseline characteristics and treatments of the 4 groups divided according to different blood pressure status. In general, patients with antecedent hypertension were older, heavier, and more often female, also had longer onset-to-admission time, higher prevalence of previous medical histories, higher Killip class, and were more likely to receive percutaneous coronary intervention, clopidogrel, heparin, and antihypertensive medication (all $P < 0.001$) than patients without hypertension, no matter with admission SBP > 108 or ≤108 mmHg.

The 7- and 30-day Outcomes

Table 2 shows the 7- and 30-day outcomes. Overall the 7- and 30-day all-cause mortality rates were 8.4% and 10.5%, respectively. The incidence of 7- and 30-day mortality and cardiac shock were significantly higher in patients with antecedent hypertension than these without hypertension, no matter with admission SBP > 108 or ≤108 mmHg (all $P < 0.001$). On the other hand, patients with admission SBP ≤ 108 mmHg had significant higher 7- and 30-day mortality, cardiac arrest, and cardiac shock rate than these with SBP > 108 mmHg, no matter with or without antecedent hypertension (all $P < 0.001$). Particularly, the total admission cardiac shock rate was 3.7%, which occurred mainly in patients with admission SBP ≤ 108 mmHg ($P < 0.001$), and after we excluded these patients, the 7- and 30-day mortality were still significant higher in patients with low admission SBP and antecedent hypertension (all $P < 0.001$).

Figure 1 displays the Kaplan–Meier curves for 30-day all-cause mortality. Analysis using the log-rank test revealed

Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.

TABLE 1. Baseline Characteristics and Treatments of Patients According to Different Blood Pressure Groups

		SBP > 108 mmHg		SBP ≤ 108 mmHg	
Variable	**All Patients**	**Without Hypertension**	**Hypertension**	**Without Hypertension**	**Hypertension**
Number of patients	7303	3164 (55.6%)	2527 (44.4%)	1170 (72.6%)	442 (27.4%)
Age, years*	62.6 ± 11.9	61.3 ± 12.5	64.0 ± 10.9	62.3 ± 12.0	65.4 ± 10.2
Gender (male)*	5184 (71.0%)	2384 (75.3%)	1665 (65.9%)	839 (71.7%)	296 (67.0%)
Weight, kg*	66.6 ± 11.8	65.9 ± 11.4	68.7 ± 11.9	63.4 ± 11.3	67.8 ± 12.2
Heart rate, bpm*	77.5 ± 18.5	77.6 ± 16.7	79.7 ± 17.7	73.6 ± 21.5	74.4 ± 24.2
Systolic blood pressure, mmHg*	126.3 ± 25.4	130.4 ± 16.7	142.2 ± 21.8	93.5 ± 11.4	93.3 ± 11.8
Diastolic blood pressure, mmHg*	78.9 ± 15.9	81.0 ± 12.2	87.3 ± 14.7	61.9 ± 10.5	61.3 ± 10.6
Onset-to-admission time, hours†	5.1 (3.1–8.2)	5.0 (3.0–8.1)	5.3 (3.2–8.3)	5.0 (2.6–8.1)	5.2 (3.2–8.3)
Medical histories (n, %)					
Myocardial infarction*	580 (7.9%)	208 (6.6%)	231 (9.1%)	88 (7.5%)	53 (12.0%)
Diabetes mellitus*	825 (11.3%)	260 (8.2%)	394 (15.6%)	93 (7.9%)	78 (17.6%)
Heart failure*	195 (2.7%)	48 (1.5%)	103 (4.1%)	22 (1.9%)	22 (5.0%)
Stroke*	680 (9.3%)	157 (5.0%)	382 (15.1%)	64 (5.5%)	77 (17.4%)
Killip class (n, %)*					
I	5993 (82.1%)	2724 (86.1%)	2092 (82.8%)	889 (76.0%)	288 (65.2%)
II	988 (13.5%)	380 (12.0%)	368 (14.6%)	158 (13.5%)	82 (18.6%)
III	146 (2.0%)	49 (1.5%)	61 (2.4%)	19 (1.6%)	17 (3.8%)
IV	176 (2.4%)	11 (0.3%)	6 (0.2%)	104 (8.9%)	55 (12.4%)
Treatment (n, %)					
Thrombolysis*	3820 (52.3%)	1748 (55.2%)	1191 (47.1%)	664 (56.8%)	217 (49.1%)
PTCA*	852 (11.7%)	321 (10.1%)	357 (14.1%)	114 (9.7%)	60 (13.6%)
Aspirin*	6996 (95.8%)	3056 (96.6%)	2438 (96.5%)	1098 (93.8%)	404 (91.4%)
Clopidogrel*	2048 (28.0%)	824 (26.0%)	795 (31.5%)	293 (25.0%)	136 (30.8%)
Heparin or LMWH‡	4484 (61.4%)	1912 (60.4%)	1583 (62.6%)	704 (60.2%)	285 (64.5%)
Beta-blocker*	4483 (61.4%)	2007 (63.4%)	1703 (67.4%)	558 (47.7%)	215 (48.6%)
ACEI or ARB*	5236 (71.7%)	2299 (72.7%)	2062 (81.6%)	618 (52.8%)	257 (58.1%)
Calcium channel blocker*	930 (12.7%)	370 (11.7%)	425 (16.8%)	87 (7.4%)	48 (10.9%)
Statin*	5219 (71.5%)	2315 (73.2%)	1852 (73.3%)	763 (65.2%)	289 (65.4%)
Nitrate*	6716 (92.0%)	2968 (93.8%)	2389 (94.5%)	994 (85.0%)	365 (82.6%)
Diuretic*	1858 (25.4%)	649 (20.5%)	716 (28.3%)	328 (28.0%)	165 (37.3%)
Electrocardiogram location (n, %)*					
New left bundle-branch block	49 (0.7%)	25 (0.8%)	16 (0.6%)	3 (0.3%)	5 (1.1%)
V1–V6	3857 (52.8%)	1808 (57.1%)	1356 (53.7%)	538 (46.0%)	155 (35.1%)
II, III, avF, or V7–V9	3250 (44.5%)	1267 (40.0%)	1092 (43.2%)	617 (52.7%)	274 (62.0%)
I, avL	147 (2.0%)	64 (2.0%)	63 (2.5%)	12 (1.0%)	8 (1.8%)

ACEI = angiotensin-converting enzyme inhibitor, ARB = angiotensin receptor blocker, LMWH = low molecular weight heparin, PTCA = percutaneous coronary intervention, SBP = systolic blood pressure.

* $P < 0.001$.

† $P = 0.001$.

‡ $P = 0.143$.

significant differences among different blood pressure groups ($P < 0.001$) with a significantly higher cumulative mortality rate in patients with low admission SBP and antecedent hypertension than in the other groups (Figure 1A). Similar pattern occurred with patients after we excluded these with admission cardiac shock ($P < 0.001$) (Figure 1B).

Predictors of 7- and 30-day all-Cause Mortality Using Multivariate Cox Analysis

Table 3 shows the association of different blood pressure status with 7- and 30-day mortality based on the optimal final multivariate Cox models. After adjusting for age, gender, medical histories, admission vital signs, reperfusion strategy, and main medications, low admission SBP and antecedent hypertension group was still an independent risk factor predicting 7-day all-cause mortality (HR 1.86, 95% CI 1.41–2.46; $P < 0.001$) and 30-day all-cause mortality (HR 1.88, 95% CI 1.46–2.43; $P < 0.001$). Low admission SBP was a significant predictor of mortality in overall patients, and no matter in patients with admission SBP > 108 or ≤108 mmHg, history of antecedent hypertension increased the risk of 7- and 30-day all-cause mortality than these without hypertension (all $P < 0.05$) (Figure 2).

Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.

TABLE 2. The 7- and 30-day Outcomes According to Different Blood Pressure Groups

Outcomes	All Patients	SBP > 108 mmHg		SBP ≤ 108 mmHg		*P* Value
		Without Hypertension	Hypertension	Without Hypertension	Hypertension	
7-day events						
All-cause mortality	613 (8.4%)	182 (5.8%)	174 (6.9%)	173 (14.8%)	84 (19.0%)	<0.001
Re-infarction	108 (1.5%)	50 (1.6%)	42 (1.7%)	8 (0.7%)	8 (1.8%)	0066
Cardiac arrest	94 (1.3%)	33 (1.0%)	19 (0.8%)	30 (2.6%)	12 (2.7%)	<0.001
Cardiac shock	422 (5.8%)	86 (2.7%)	77 (3.0%)	179 (15.3%)	80 (18.1%)	<0.001
Stroke	46 (0.6%)	16 (0.5%)	18 (0.7%)	6 (0.5%)	6 (1.4%)	0.182
30-day events						
All-cause mortality	764 (10.5%)	225 (7.1%)	246 (9.7%)	195 (16.7%)	98 (22.2%)	<0.001
Re-infarction	144 (2.0%)	66 (2.1%)	59 (2.3%)	11 (0.9%)	8 (1.8%)	0.024
Cardiac arrest	113 (1.5%)	40 (1.3%)	28 (1.1%)	33 (2.8%)	12 (2.7%)	<0.001
Cardiac shock	456 (6.2%)	98 (3.1%)	90 (3.6%)	185 (15.8%)	83 (18.8%)	<0.001
Stroke	64 (0.9%)	19 (0.6%)	27 (1.1%)	7 (0.6%)	11 (2.5%)	0.002
Admission cardiac shock	273 (3.7%)	32 (1.0%)	35 (1.4%)	148 (12.6%)	58 (13.1%)	<0.001
7-day mortality*	447 (6.4%)	166 (5.3%)	149 (6.0%)	88 (8.6%)	44 (11.5%)	<0.001
30-day mortality*	590 (8.4%)	208 (6.6%)	219 (8.8%)	108 (10.6%)	55 (14.3)	<0.001

SBP = systolic blood pressure.
* All-cause mortality was calculated after excluding patients with admission cardiac shock (n = 273), so the patients number were 7030.

DISCUSSION

This is one of the largest studies evaluating the impact of admission SBP and antecedent hypertension on short-term outcomes in patients with STEMI. Unlike previous research on the topic, we combined these 2 risk factors and fond that low admission SBP was the relatively dominant contributor for predicting 7- and 30-day all-cause mortality, and a concurrent antecedent hypertension increased the corresponding risk of mortality.

Our study revealed a 40.7% prevalence of hypertension among STEMI patients. This value is lower than that reported in general ACS population which varies from 46.0% to 63.4%.[1–4] It should be noted that the prevalence of hypertension also depends on the study circumstances. Recent studies focused mainly on patients with STEMI submitted to primary angioplasty, in which a previous history of hypertension ranged from 42.1% to 53.4%.[9,10,23] Although in the era of thrombolysis, data from the GISSI-2 (Gruppo Italiano per lo Studio della Sopravvivenza nell'Infarto Miocardico) study showed in AMI patients a prevalence of hypertension of 30.9%,[5] and the GUSTO-I (Global Utilization of Streptokinase and t-PA for Occluded Coronary Arteries) study reported a 38.1% prevalence of hypertension in STEMI patients.[18] In keeping with previous observations, our STEMI patients with hypertension are more likely to be older, female, and having longer onset-to-admission time, higher prevalence of comorbidities such as prior myocardial infarction, diabetes mellitus, heart failure, and stroke than these without hypertension.[9,23]

Many studies evaluated the prognostic value of antecedent hypertension in patients with AMI but came to inconsistent results. In the GISSI-2 study, in-hospital and 6-month mortality in hypertensive AMI patients treated with thrombolysis was significantly higher compared with normotensive patients as was the rate of left ventricular failure, recurrent angina, and

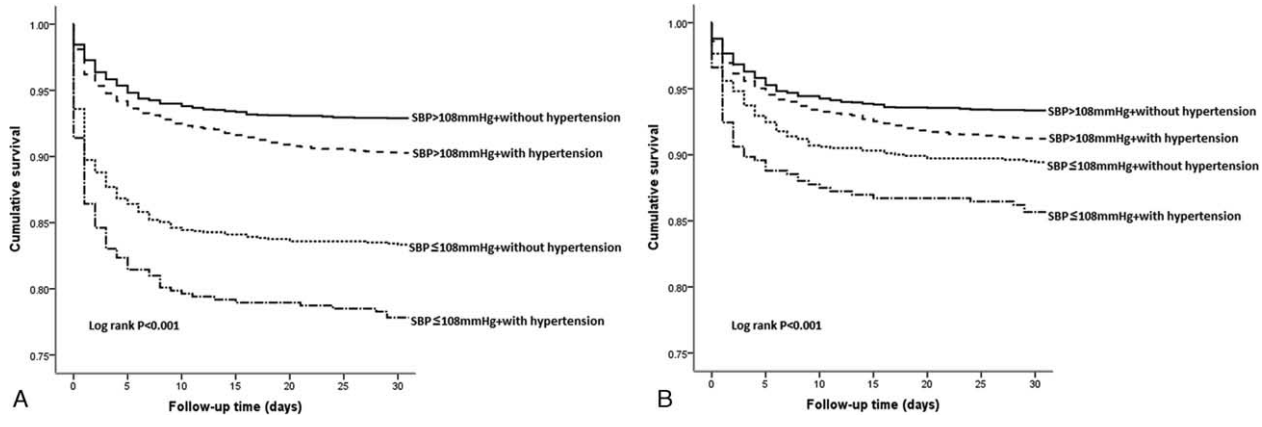

FIGURE 1. Kaplan–Meier curves for 30-day all-cause mortality according to different blood pressure groups. (A) Survival curves of the four groups, (B) Survival curves of the four groups after excluding patients with admission cardiac shock. SBP = systolic blood pressure.

Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.

TABLE 3. Predictors of 7- and 30-day All-Cause Mortality by Multivariate Cox Analysis*

	7-day All-Cause Mortality			30-day All-Cause Mortality		
Variable	**HRs**	**95% CI**	***P* Value**	**HRs**	**95% CI**	***P* Value**
Age, per year	1.04	1.03–1.05	<0.001	1.05	1.04–1.05	<0.001
Gender (female vs male)	1.44	1.22–1.70	<0.001	1.34	1.15–1.55	<0.001
Heart rate, per bpm	1.01	1.00–1.01	<0.001	1.01	1.00–1.01	<0.001
History of diabetes mellitus	1.36	1.09–1.69	0.006	1.32	1.09–1.61	0.005
History of stroke				1.21	0.98–1.49	0.075
Killip class (vs class I)						
II	1.23	0.98–1.54	0.073	1.21	1.00–1.47	0.055
III	1.53	1.06–2.22	0.025	1.44	1.04–2.00	0.028
IV	3.10	2.34–4.11	<0.001	3.15	2.41–4.10	<0.001
Electrocardiogram location (vs new LBBB)						
V1–V6	2.02	0.83–4.89	0.121	2.05	0.97–4.37	0.062
II, III, avF, or V7–V9	1.09	0.45–2.67	0.852	1.17	0.55–2.52	0.685
I, avL	1.95	0.72–5.26	0.187	1.66	0.70–3.97	0.254
PTCA	0.26	0.14–0.46	<0.001	0.38	0.25–0.58	<0.001
Aspirin						
Beta-blocker	0.55	0.46–0.66	<0.001	0.79	0.62–1.00	0.052
ACEI or ARB	0.42	0.35–0.50	<0.001	0.61	0.52–0.72	<0.001
Calcium channel blocker	0.45	0.32–0.62	<0.001	0.51	0.43–0.60	<0.001
Stain	0.61	0.51–0.72	<0.001	0.55	0.42–0.71	<0.001
Diuretic	1.38	1.16–1.65	<0.001	0.64	0.55–0.74	<0.001
Nitrate	0.75	0.60–0.94	0.013	1.67	1.43–1.96	<0.001
Blood pressure groups (vs SBP > 108 mmHg + without hypertension)						
SBP > 108 mmHg + with hypertension	1.17	0.95–1.45	0.147	1.27	1.05–1.53	0.012
SBP ≤ 108 mmHg + without hypertension	1.49	1.18–1.87	0.001	1.51	1.23–1.87	<0.001
SBP ≤ 108 mmHg + with hypertension	1.86	1.41–2.46	<0.001	1.88	1.46–2.43	<0.001

ACEI = angiotensin-converting enzyme inhibitor, ARB = angiotensin receptor blocker, CI = confidence interval, HR = hazard ratio, LBBB = left bundle-branch block, PTCA = percutaneous coronary intervention, SBP = systolic blood pressure.

* All covariables from the baseline characteristics including gender, age, weight, heart rate, diastolic blood pressure, onset-to-admission time, previous medical histories (myocardial infarction, diabetes mellitus, heart failure, and stroke), Killip class, electrocardiogram location, reperfusion strategies (PTCA and thrombolysis), and medications (aspirin, clopidogrel, heparin, beta-blocker, ACEI/ARB, calcium channel blocker, statin, nitrate, and diuretic) were adjusted in the Cox proportional hazard regression by using backward LR method. Above are the final optimal multivariate models.

reinfarction.[5] Richards et al[6] also reported higher inpatient and postdischarged mortality together with more heart failure mainly due to neurohumoral activation and early ventricular remodeling in hypertensive AMI patients in the thrombolytic era. In the Korea Acute Myocardial Infarction Registry study, 45.0% of STEMI patients had hypertension, and in multivariate analysis antecedent hypertension independently contributed to higher in-hospital mortality in patients with AMI but not to 1-year mortality.[8] Recently, De Luca et al[9] reported that among STEMI patients undergoing primary angioplasty hypertension is independently associated with higher mortality, reinfarction, stent thrombosis, and target-vessel revascularization at a follow-up of median 1200 days. On the other hand, Abrignani et al[12] stated that hypertensive subjects with first AMI have a better in-hospital outcome than age- and gender-matched normotensive subjects, perhaps due to a less severe extension of the infarction area or to a different pathophysiologic mechanism. A more recent study by Erne et al[17] also came to result that preexisting hypertension was associated with an improved in-hospital prognosis after adjustment for baseline risk in ACS patients. Other studies did not show relevant difference for short- or long-term mortality in hypertensive and normotensive patients with AMI.[2,10,11] In our study, we found a higher rate of all-cause mortality, reinfarction, cardiac shock, and stroke in patients with hypertension than these without hypertension at 7- and 30-day after hospitalization.

Compared with antecedent hypertension, lower admission SBP more often emerges as the dominant contributor or predictor of mortality in many multivariable risk score models for AMI. For instance, in the TIMI risk score for STEMI, SBP < 100 mmHg was given 3 points as a powerful contributor to the model predicting 30-day mortality, but hypertension did not,[13] and in the Acute Coronary Treatment and Intervention Outcomes Network Registry-Get With The Guidelines prediction score for AMI, different levels of low SBP were given corresponding high points for in-hospital mortality.[16] In the PRavastatin Or atorVastatin Evaluation and Infection Therapy-TIMI 22 trial, a J- or U-shaped curve association was found between blood pressure and risk of future cardiovascular events, with the lowest event rates in the SBP range of 130 to

Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.

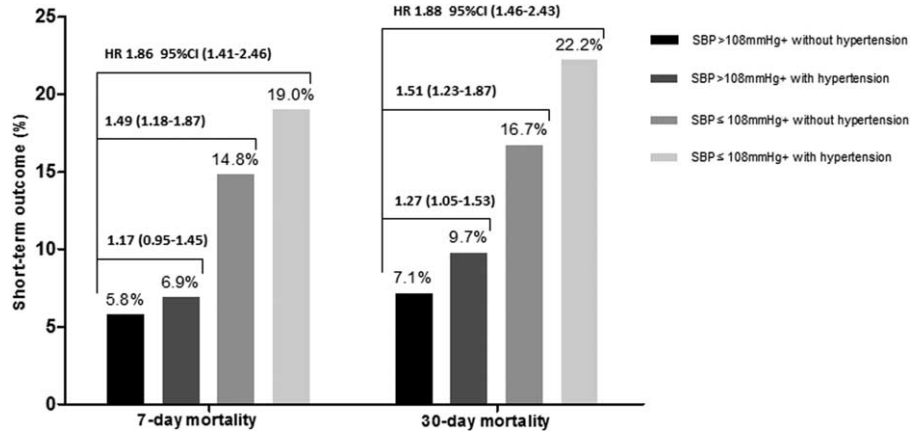

FIGURE 2. Rates of 7- and 30-day all-cause mortality according to different blood pressure groups and their multivariate-adjusted corresponding HR as reference to the group of SBP > 108 mmHg without hypertension. HR = hazard ratios, SBP = systolic blood pressure.

140 mmHg and diastolic blood pressure of 80 to 90 mmHg, and a flat curve for SBP of 110 to 130 mmHg and diastolic blood pressure of 70 to 90 mmHg, which suggests that too low pressure (especially <110/70 mmHg) may be dangerous in ACS patients.[21] Besides, in the Global Use of Strategies To Open occluded arteries in ACSs (GUSTO-IIb) and Receptor Suppression Using Integrelin Therapy (PURSUIT) trial, a value of SBP lower than 90 mmHg was strongly associated with 48-hour and 30-day mortality.[24] In our study, a threshold of SBP lower than 108 mmHg was determined to predict 30-day all-cause mortality. More importantly, we found that low admission SBP was the relatively dominant contributor for predicting 7- and 30-day all-cause mortality, and a concurrent antecedent hypertension increased the corresponding risk of mortality. This trend was maintained even after we excluded patients with admission cardiac shock.

In the current study, we performed a receiver-operating characteristic curve and found that admission SBP 108 mmHg was the best cutoff for predicting 30-day mortality. On this basis, patients were divided into 4 groups according to the status of admission SBP and antecedent hypertension. Such subsequent observational analysis was inevitable resulted in the very heterogeneous baseline characteristics that might affect clinical outcome. In order to further confirm our results, a propensity score matching was used to adjust for differences in baseline characteristics between groups (Supplemental Tables 1–3, http://links.lww.com/MD/A392). After propensity score matching, low admission SBP (≤108 mmHg) was still the dominant contributor for predicting 7- and 30-day all-cause mortality. However, interpretation of the results that the risk derived from antecedent hypertension had been weakened and even disappeared should be treated with caution, since after the strict matching we have lost a lot of samples which limited the test power.

Several limitations should be mentioned when evaluating the results of study. First, this is a retrospective observational analysis of the impact of antecedent hypertension and admission SBP on short-term outcomes in STEMI patients. As is inherent in such study design, our study could not come to a definite cause-effect relationship but suggest a possible prognostic marker. Second, owing to insufficient guideline implementation, only 52.3% of the patients received thrombolysis and only 11.7% had percutaneous coronary intervention treatment. Our results might not be generalizable to patients with STEMI receiving standard reperfusion therapy and medications, thus prospective studies in contemporary era are needed to confirm our results. Third, levels of creatine kinase-MB and troponin I as well as left ventricular ejection fraction were not collected at admission, and detailed information about the duration and control of hypertension before admission were also not available, and these data might be of prognostic significance after myocardial infarction. At last, the follow-up period in our study was limited to 30 days, and a longer follow-up period may have provided additional data.

ACKNOWLEDGMENTS

The authors would like to thank the entire physicians serve as principal investigators and all the study coordinators from every hospital for their invaluable dedication and cooperation, as well as all the patients who participated in this multicenter study.

REFERENCES

1. Frazier CG, Shah SH, Armstrong PW, et al. Prevalence and management of hypertension in acute coronary syndrome patients varies by sex: observations from the Sibrafiban versus aspirin to Yield Maximum Protection from ischemic Heart events postacute cOroNary sYndromes (SYMPHONY) randomized clinical trials. *Am Heart J.* 2005;150:1260–1267.
2. Bertomeu V, Cabades A, Morillas P, et al. Clinical course of acute myocardial infarction in the hypertensive patient in Eastern Spain: the PRIMVAC registry. *Heart Lung.* 2006;35:20–26.
3. Ali WM, Zubaid M, El-Menyar A, et al. The prevalence and outcome of hypertension in patients with acute coronary syndrome in six Middle-Eastern countries. *Blood Pressure.* 2011;20:20–26.
4. Dorobantu M, Tautu OF, Fruntelata A, et al. Hypertension and acute coronary syndromes in Romania: data from the ISACS-TC registry. *Eur Heart J Suppl.* 2014;16:A20–A27.
5. Fresco C, Avanzini F, Bosi S, et al. Prognostic value of a history of hypertension in 11,483 patients with acute myocardial infarction treated with thrombolysis. GISSI-2 Investigators. Gruppo Italiano per lo Studio della, Sopravvivena nell'Infarto Miocardico. *J Hypertens.* 1996;14:743–750.
6. Richards AM, Nicholls MG, Troughton RW, et al. Antecedent hypertension and heart failure after myocardial infarction. *J Am Coll Cardiol.* 2002;39:1182–1188.

Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.

7. Dumaine R, Gibson CM, Murphy SA, et al. Association of a history of systemic hypertension with mortality, thrombotic, and bleeding complications following non-ST-segment elevation acute coronary syndrome. *J Clin Hypertens (Greenwich).* 2006;8:315–322.
8. Kang DG, Jeong MH, Ahn Y, et al. Clinical effects of hypertension on the mortality of patients with acute myocardial infarction. *J Korean Med Sci.* 2009;24:800.
9. De Luca G, Dirksen MT, Spaulding C, et al. Impact of hypertension on clinical outcome in STEMI patients undergoing primary angioplasty with BMS or DES. *Int J Cardiol.* 2014;175:50–54.
10. Cecchi E, D Alfonso MG, Chiostri M, et al. Impact of hypertension history on short and long-term prognosis in patients with acute myocardial infarction treated with percutaneous angioplasty: comparison between STEMI and NSTEMI. *High Blood Press Cardiovasc Prevent.* 2014;21:37–43.
11. Majahalme SK, Smith DE, Cooper JV, et al. Comparison of patients with acute coronary syndrome with and without systemic hypertension. *Am J Cardiol.* 2003;92:258–263.
12. Abrignani MG, Dominguez LJ, Biondo G, et al. In-hospital complications of acute myocardial infarction in hypertensive subjects. *Am J Hypertens.* 2005;18:165–170.
13. Morrow DA, Antman EM, Charlesworth A, et al. TIMI risk score for ST-elevation myocardial infarction: a convenient, bedside, clinical score for risk assessment at presentation: an intravenous nPA for treatment of infarcting myocardium early II trial substudy. *Circulation.* 2000;102:2031–2037.
14. Addala S, Grines CL, Dixon SR, et al. Predicting mortality in patients with ST-elevation myocardial infarction treated with primary percutaneous coronary intervention (PAMI risk score). *Am J Cardiol.* 2004;93:629–632.
15. Halkin A, Singh M, Nikolsky E, et al. Prediction of mortality after primary percutaneous coronary intervention for acute myocardial infarction: the CADILLAC risk score. *J Am Coll Cardiol.* 2005;45:1397–1405.
16. Chin CT, Chen AY, Wang TY, et al. Risk adjustment for in-hospital mortality of contemporary patients with acute myocardial infarction: the acute coronary treatment and intervention outcomes network (ACTION) registry-get with the guidelines (GWTG) acute myocardial infarction mortality model and risk score. *Am Heart J.* 2011;161:113.e2–122.e2.
17. Erne P, Radovanovic D, Schoenenberger AW, et al. Impact of hypertension on the outcome of patients admitted with acute coronary syndrome. *J Hypertens.* 2015;33:860–867.
18. Aylward PE, Wilcox RG, Horgan JH, et al. Relation of increased arterial blood pressure to mortality and stroke in the context of contemporary thrombolytic therapy for acute myocardial infarction. A randomized trial. GUSTO-I Investigators. *Ann Intern Med.* 1996;125:891–900.
19. Jonas M, Grossman E, Boyko V, et al. Relation of early and one-year outcome after acute myocardial infarction to systemic arterial blood pressure on admission. *Am J Cardiol.* 1999;84:162–165.
20. Thune JJ, Signorovitch J, Kober L, et al. Effect of antecedent hypertension and follow-up blood pressure on outcomes after high-risk myocardial infarction. *Hypertension.* 2008;51:48–54.
21. Bangalore S, Qin J, Sloan S, et al. What is the optimal blood pressure in patients after acute coronary syndromes?: Relationship of blood pressure and cardiovascular events in the PRavastatin OR atorVastatin Evaluation and Infection Therapy-Thrombolysis In Myocardial Infarction (PROVE IT-TIMI) 22 trial. *Circulation.* 2010;122:2142–2151.
22. Alpert JS, Thygesen K, Antman E, et al. Myocardial infarction redefined – a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. *J Am Coll Cardiol.* 2000;36: 959–969.
23. De Luca G, Van'T Hof AWJ, Huber K, et al. Impact of hypertension on distal embolization, myocardial perfusion, and mortality in patients with ST segment elevation myocardial infarction undergoing primary angioplasty. *Am J Cardiol.* 2013;112:1083–1086.
24. Chang WC, Boersma E, Granger CB, et al. Dynamic prognostication in non-ST-elevation acute coronary syndromes: insights from GUSTO-IIb and PURSUIT. *Am Heart J.* 2004;148:62–71.

Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.