

BMJ Open Clinical characteristics and short-term outcomes in patients with elevated admission systolic blood pressure after acute ST-elevation myocardial infarction: a population-based study

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ABSTRACT

Objective: Prognostic value of lower admission systolic blood pressure (SBP) in patients with acute myocardial infarction has been confirmed, but the impact of elevated admission SBP on short-term outcomes has been evaluated only by a limited number of studies and they have reported conflicting results. The aim of our study was to investigate the characteristics and short-term outcomes in patients with elevated admission SBP after ST-elevation myocardial infarction (STEMI).

Design: A population-based, observational study.

Setting: The multicentre registry in China.

Participants: A total of 7510 consecutive patients with STEMI were registered. Patients were divided into three groups according to admission SBP: normal admission SBP (100–139 mm Hg), modestly elevated admission SBP (140–179 mm Hg) and excessively elevated admission SBP (≥ 180 mm Hg). The primary outcomes were 7-day and 30-day all-cause mortality, major adverse cardiac events (MACE) and bleeding rate.

Results: Of 6591 patients, 4182 (63.5%) had normal admission SBP, 2187 (33.2%) modestly elevated admission SBP and 222 (3.4%) excessively elevated admission SBP. Patients with elevated admission SBP had a high-risk profile, such as were more likely to be older, with more concomitant cardiovascular morbidities, presenting with more events of anterior myocardial infarction and less reperfusion treatment. However, 7-day and 30-day all-cause mortality, MACE and bleeding rate were comparable among groups (all $p > 0.05$). Survival curves and MACE curves were similar among groups ($p = 0.377$ and 0.375 , respectively). After multivariate adjustment, elevated admission SBP was not associated with increased risk of short-term death and bleeding, and MACE was comparable with normal admission SBP.

Conclusions: Although those with elevated admission SBP after STEMI were at a higher risk for cardiovascular events, they did not have poorer short-term outcomes compared with patients with normal admission SBP.

Strengths and limitations of this study

- This large sample study revealed that patients with elevated admission systolic blood pressure (SBP) after ST-elevation myocardial infarction (STEMI) did not have a poorer short-term prognosis compared with those with normal admission SBP although they had high profile for cardiovascular events.
- Data of SBP were collected at admission only, whereas detailed treatment and blood pressure control levels during hospitalisation and after discharge that might relate to the prognosis were not available.
- Other data such as left ventricular mass, left ventricular ejection fraction and biomarkers of myocardial necrosis that were valuable parameters for evaluating prognosis were lacking.
- The follow-up time in our study was short-term and a long-term follow-up is required to evaluate the long-term prognostic value of elevated admission SBP in patients with STEMI.

INTRODUCTION

Effective risk stratification on admission is significant for acute coronary syndrome (ACS) to provide more accurate prognostic information and guide treatment more appropriately.^{1 2} It has been widely accepted that blood pressure plays an important role in the prognosis of ACS and has become a vital factor for assessing risk in several risk scores,^{3–5} including TIMI score and GRACE score, the most widely used risk scores, in which lower systolic blood pressure (SBP) is associated with a poor short-term prognosis. However, a limited number of studies have evaluated the prognostic value of elevated admission SBP and have reported conflicting results. Some studies^{6 7} reported that the admission SBP was inversely associated with the outcome; while others^{8 9} reported

admission SBP in a certain interval with optimal outcome.

As the pathogenesis of ACS is a complicated pathophysiological process accompanying intricate neuroendocrine alterations,¹⁰ blood pressure level after myocardial infarction is a reflection of integrated cardiovascular system and neuroendocrine system. Some previous studies^{11–16} have shown that elevated admission blood pressure is associated with increased risk of intracerebral haemorrhage in patients with ST-segment elevation myocardial infarction (STEMI) following thrombolytic therapy; and elevated blood pressure during or after the procedure is an independent risk factor for minor bleeding and haematoma in patients who undergo percutaneous coronary intervention (PCI) and angiography.^{17 18} Moreover, significant hypertension on presentation (SBP >180 mm Hg or diastolic blood pressure (DBP) >110 mm Hg) is a relative contraindication for thrombolysis in current guidelines for management of STEMI.¹⁹ A risk–benefit assessment may compromise the use of reperfusion strategies for those with elevated, especially excessively elevated, admission blood pressure in daily clinical practice. Moreover, elevated systemic blood pressure results in increased myocardial oxygen consumption, worsening the imbalance between oxygen supply and myocardial metabolic demand, which goes against the prognosis. In addition, elevated blood pressure is associated with more severe complications such as cardiac rupture.²⁰ Therefore, we hypothesised that elevated admission SBP, especially excessively elevated SBP after acute myocardial infarction, was associated with a poor short-term outcome. To test this hypothesis, we analysed retrospectively a large sample of patients with STEMI from a prospectively designed multihospital database in China and evaluated the impact of elevated admission SBP on the short-term outcomes in patients with STEMI.

METHODS

Study population

From July 2001 to July 2004, 7510 consecutive patients presenting with acute STEMI within 12 h from the onset of symptoms in 247 hospitals in China were enrolled. STEMI was defined as: chest pain or equivalent symptoms in combination with dynamic ECG changes consistent with STEMI (in the presence of ST elevation >0.1 mV in ≥ 2 extremity leads or >0.2 mV in ≥ 2 precordial leads, or accompanying with left bundle branch block morphology), and increased serum biochemical markers of cardiac necrosis, including creatine kinase-MB and troponin I. All participants provided their written informed consent.

Of the 7510 patients, 123 patients were excluded because of incomplete data. In addition, a total of 796 patients with admission SBP <100 mm Hg were excluded because they belonged to a well-defined group known to have a poor outcome according to previous studies.^{3 5 21}

The remaining 6591 patients were divided into three groups according to admission SBP: normal SBP group (SBP 100–139 mm Hg), modestly elevated SBP group (SBP 140–179 mm Hg) and excessively elevated SBP group (SBP ≥ 180 mm Hg).

Procedural characteristics

After admission, patients received therapy including aspirin, clopidogrel, heparin, ACE inhibitors or angiotensin receptors blockers (ARB), nitrates, β blockers, calcium channel blockers (CCB) and statins as far as possible to comply with the current guidelines for treatment of STEMI. Those who were suitable for reperfusion therapy were treated with thrombolysis or PCI according to the clinical circumstances.

Demographic data and epidemiological variables were collected at admission. The baseline data included gender, age, weight, heart rate, blood pressure, blood glucose, cardiovascular histories (myocardial infarction, stroke, hypertension and heart failure), location of myocardial infarction and Killip class, methods of reperfusion therapy, as well as drugs used during hospitalisation and follow-up.

Study end points and definitions

The primary outcome measure was all-cause death within 7 and 30 days after myocardial infarction. The secondary outcomes included: (1) major adverse cardiac events (MACE) that were composite of death, cardiogenic shock, recurrent myocardial ischaemia, myocardial reinfarction and stroke within 7 and 30 days after myocardial infarction; (2) bleeding events including major bleeding and minor bleeding within 7 and 30 days after myocardial infarction.

The definition of different cardiac events was as following: cardiogenic shock was defined as persistent hypotension (SBP <90 mm Hg) that did not respond to fluid titration and required an intra-aortic balloon pump or intravenous inotropic therapy. Recurrent myocardial ischaemia was defined as recurrent chest pain with new ECG changes. Reinfarction was defined as recurrent typical chest pain with new ischaemic ECG changes (ST re-elevation or depression, or new Q waves) and a further increase in enzyme levels (to twice the upper limit of normal if it had returned to baseline or if already elevated, with a further elevation by 50%). Stroke was defined as focal neurological deficits that persisted for more than 24 h and were confirmed by CT scans or MRI. Bleeding was defined according to the Bleeding Academic Research Consortium (BARC) definitions²² as: type 1 is in which the patient does not seek treatment; type 2 is in which intervention or admission to hospital occurs; type 3a is overt bleeding plus haemoglobin drop of 3 to less than 5 g/dL or transfusion; type 3b is overt bleeding plus haemoglobin drop of at least 5 g/dL, cardiac tamponade, bleeding requiring surgical intervention or intravenous vasoactive agents; type 3c is intracranial haemorrhage or intraocular bleeding

compromising vision; type 4 is coronary artery bypass grafting-related bleeding and type 5 is fatal bleeding. Owing to limited availability of data and lack of data about coronary artery bypass grafting-related bleeding, we analysed the data of type 1, type 2, type 3 and type 5 bleeding.

Patients with elevated admission SBP were compared with those with normal admission SBP in terms of clinical characteristics and 7-day and 30-day outcomes.

Statistical analysis

The baseline characteristics of patients were presented with mean±SD for continuous variables and compared by one-way analysis of variance, and with Bonferroni correction if the data were of normal distribution, otherwise Wilcoxon signed-rank test was used. Categorical variables presented as percentage were compared by Pearson χ^2 test. Multivariate logistic regression analysis was used to analyse the factors associated with short-term bleeding events. Cumulative survival and MACE curves were constructed using the Kaplan-Meier method. Log-rank tests were used to compare the curves of groups. Cox proportional hazard regression models were used to identify whether there was an association between different SBP levels on admission and prognosis and the models were corrected for age, sex, cardiovascular histories (myocardial infarction, hypertension, stroke and heart failure), heart rate, DBP, haemoglobin, blood sugar, Killip class, location of myocardial infarction, reperfusion strategies and drugs used during hospitalisation mainly including anticoagulants, ACE inhibitors (or ARB), β blockers and CCB. The adjusted HRs with their respective 95% CIs for each group were calculated with reference to the normal SBP group, for which the HR was considered as 1. All statistical tests were two-tailed, and p values were statistically significant at <0.05. All statistical analyses were carried out using the SPSS statistical software, V.19.0 (SPSS Inc., Chicago, Illinois, USA).

RESULTS

Baseline characteristics

Of the 6591 patients included in this study, 4696 (71.2%) were men and 1895 (28.8%) were women, with a mean age of 60.13±12.11 and 68.05±9.10 years, respectively. When these patients were divided according to admission SBP, 4182 (63.5%) had normal admission SBP (100–139 mm Hg), 2187 (33.2%) modestly elevated admission SBP (140–179 mm Hg) and 222 (3.4%) excessively elevated admission SBP (≥ 180 mm Hg).

Table 1 shows the baseline characteristics of the three groups divided according to admission SBP. It was found that compared with patients with normal admission SBP, those with elevated admission SBP were more likely to be older, of female gender and tended to have more concomitant cardiovascular morbidities such as hypertension, heart failure and histories of stroke and myocardial infarction. This was true especially for patients with

excessively elevated SBP; 77.9% of these patients had a history of hypertension, significantly higher than that of patients with normal admission SBP (32.6%) or patients with modestly elevated admission SBP (57.4%; $p < 0.001$). At admission, patients with excessively elevated SBP had a higher heart rate, haemoglobin, blood sugar, as well as a higher percentage of patients with Killip class >1 compared with patients with normal SBP. Also, a higher proportion of anterior wall myocardial infarction was found in patients with elevated admission SBP. However, reperfusion treatment including thrombolysis and PCI were less frequently administered to patients with elevated admission SBP, especially those with excessively elevated SBP. In addition, anticoagulants were used less frequently in patients with elevated SBP, whereas antiplatelet therapy was comparable among the three groups. Moreover, patients with elevated SBP were more likely to be treated with β blockers, ACEI (or ARB) and CCB compared with patients with normal SBP (table 2).

Seven-day and 30-day outcomes

Figure 1 shows the 7-day and 30-day outcomes. The 7-day all-cause mortality was 6.5% in normal admission SBP group compared with 6.1% in modestly elevated SBP group and 6.3% in excessively elevated SBP group ($p = 0.842$). MACE rates within 7 days were 18.1%, 16.8% and 18.9%, respectively, with no statistical difference between the groups ($p = 0.400$). In addition, incidences of bleeding within 7 days were also comparable between the groups (3.5% in normal admission SBP group, 3.7% in modestly elevated admission SBP group and 3.6% in excessively elevated admission SBP group, $p = 0.889$).

Although the 30-day all-cause mortality in excessively elevated admission SBP group (11.3%) was higher than the other two groups (8.8% in normal admission SBP group and 8.5% in modestly elevated admission SBP group, respectively), it did not reach statistical difference ($p = 0.370$). Similarly, MACE and bleeding rates for the three groups were comparable ($p = 0.369$ and 0.886, respectively).

Table 3 shows the incidence of 7-day and 30-day bleeding events according to the BARC definition stratified by admission SBP. The incidences of type 1, type 2, type 3 as well as type 5 within 7 days were similar between the groups ($p = 0.979$). The 30-day values for the groups were also comparable ($p = 0.523$).

Table 4 displays the factors associated with 30-day bleeding events by logistic regression analysis. It was found that advanced age, low weight, thrombolysis, PCI treatment and aspirin use were independent risk factors predicting short-term bleeding events, while elevated admission SBP was not associated with increased risk of short-term bleeding compared with normal admission SBP (OR=1.108, 95% CI 0.677 to 1.816, $p = 0.683$ for modestly elevated admission SBP and OR=2.119, 95% CI 0.746 to 6.013, $p = 0.158$ for excessively elevated admission SBP, respectively).

Table 1 Baseline characteristics of patients according to the admission SBP (mm Hg)

Variable	Normal SBP (100–139) (n=4182)	Modestly elevated SBP (140–179) (n=2187)	Excessively elevated SBP (≥ 180) (n=222)	p Value
Demographics				
Age (years)	61.82 \pm 11.97	63.53 \pm 11.68	63.94 \pm 10.23	<0.001
Male (n (%))	3070 (73.4)	1492 (68.2)	134 (60.4)	<0.001
Weight (kg)	66.93 \pm 11.52	67.50 \pm 12.07	67.63 \pm 11.93	0.304
Cardiovascular disease histories				
Previous MI (n (%))	362 (8.7)	142 (6.5)	22 (9.9)	0.006
Previous DM (n (%))	461 (11.0)	251 (11.5)	33 (14.9)	0.202
Previous HTN (n (%))	1362 (32.6)	1256 (57.4)	173 (77.9)	<0.001
Previous stroke (n (%))	341 (8.2)	236 (10.8)	37 (16.7)	<0.001
Previous HF (n (%))	105 (2.5)	59 (2.7)	13 (5.9)	0.011
Admission vital signs and laboratory examination				
Heart rate (bpm)	76.40 \pm 17.38	80.05 \pm 17.30	85.33 \pm 18.65	<0.001
SBP (mm Hg)	118.03 \pm 10.90	151.36 \pm 10.32	188.73 \pm 13.99	<0.001
DBP (mm Hg)	75.21 \pm 10.12	91.73 \pm 11.91	106.47 \pm 16.24	<0.001
Hb (g/L)	135.66 \pm 20.43	136.13 \pm 21.36	139.82 \pm 22.26	0.013
Blood sugar (mmol/L)	8.34 \pm 4.04	8.54 \pm 4.12	9.09 \pm 4.59	0.008
Killip class >1 (n (%))	640 (15.3)	362 (16.6)	55 (24.8)	0.001
ST segment elevation on ECG				
V1–V6 (n (%))	2221 (53.1)	1253 (57.3)	140 (63.1)	<0.001
II, III, avF or V7–V9 (n (%))	1888 (45.1)	880 (40.2)	73 (32.9)	<0.001
I, avL (n (%))	73 (1.7)	54 (2.5)	9 (4.1)	<0.001

DBP, diastolic blood pressure; DM, diabetes mellitus; Hb, haemoglobin; HF, heart failure; HTN, hypertension; MI, myocardial infarction; SBP, systolic blood pressure.

Kaplan-Meier curves for 30-day mortality are shown in figure 2. The log-rank test reported that there was no significant difference between the three groups ($p=0.377$). Similarly, curves of MACE within 30 days showed no statistical difference between the three groups ($p=0.375$; figure 3).

Cox analysis showed that after adjusting variables that influenced the prognosis of STEMI, neither modestly elevated admission SBP nor excessively elevated admission SBP were associated with increased risk of 7-day all-cause mortality (HR=0.905, 95% CI 0.698 to 1.175,

$p=0.454$ for modestly elevated SBP, and HR=0.766, 95% CI 0.408 to 1.440, $p=0.408$ for excessively elevated SBP, respectively) and 30-day all-cause mortality (HR=0.850, 95% CI 0.681 to 1.060, $p=0.148$ for modestly elevated SBP and HR=0.920, 95% CI 0.566 to 1.495, $p=0.737$ for excessively elevated SBP, respectively) compared with normal admission SBP. Similarly, no increased risk of 7-day and 30-day MACE was found in modestly elevated admission SBP (HR=0.926, 95% CI 0.793 to 1.018, $p=0.328$ for 7-day MACE and HR=0.906, 95% CI 0.783 to 1.047, $p=0.182$ for 30-day MACE, respectively) and

Table 2 Treatment characteristics of patients according to the admission SBP (mm Hg)

Variable	Normal SBP (100–139) (n=4182)	Modestly elevated SBP (140–179) (n=2187)	Excessively elevated SBP (≥ 180) (n=222)	p Value
Reperfusion strategies				
Thrombolysis (n (%))	2252 (53.8)	1101 (50.3)	96 (43.2)	0.001
PCI (n (%))	517 (12.4)	241 (11.0)	15 (6.8)	0.018
Anticoagulants				
Heparin (or LMWH) (n (%))	3881 (92.8)	1981 (90.6)	197 (88.7)	0.035
Antiplatelet therapy				
Aspirin (n (%))	4028 (96.3)	2107 (96.3)	210 (94.6)	0.408
Clopidogrel (n (%))	1205 (28.8)	605 (27.7)	55 (24.8)	0.310
Other medications				
β Blocker (n (%))	2591 (62.0)	1485 (67.9)	152 (68.5)	<0.001
ACEI (or ARB) (n (%))	2965 (70.9)	1790 (81.8)	194 (87.4)	<0.001
Statins (n (%))	2999 (71.7)	1621 (74.1)	163 (73.4)	0.118
CCB (n (%))	499 (11.9)	329 (15.0)	50 (22.5)	<0.001

ACEI, ACE inhibitors; ARB, angiotensin receptors blockers; CCB, calcium channel blocker; LMWH, low molecular weight heparin; PCI, percutaneous coronary intervention; SBP, systolic blood pressure.

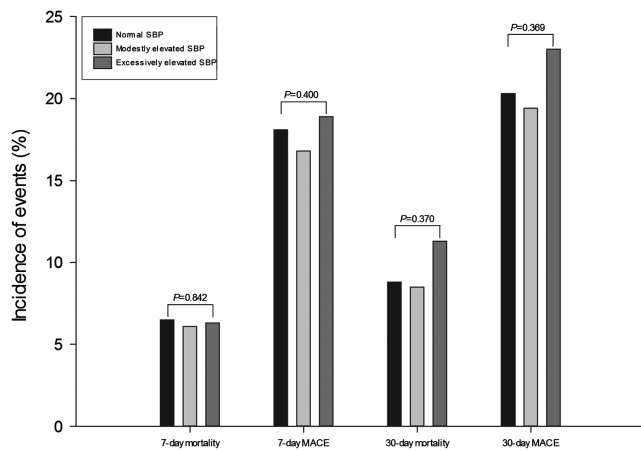


Figure 1 Outcomes of 7-day and 30-day stratified by admission SBP. MACE, major adverse cardiac events; SBP, systolic blood pressure.

excessively elevated admission SBP (HR=0.918, 95% CI 0.640 to 1.318, $p=0.644$ for 7-day MACE and HR=0.936, 95% CI 0.673 to 1.303, $p=0.696$ for 30-day MACE, respectively) compared with normal admission SBP (table 5).

DISCUSSION

The major findings of our analyses of data derived from a large sample of patients are as follows: patients with elevated admission SBP after acute STEMI were characterised with a higher risk of acute coronary events; however, they did not have poorer short-term outcomes compared with those with normal admission SBP.

As a pathological stress, a series of neurohumor reactions are aroused after ACS,²³ of which sympathetic nerve overactivation is most significant.^{24 25} Therefore, blood pressure level after myocardial infarction is a reflection of integrated cardiovascular system and neuroendocrine system. Increased catecholamine release promoted elevation of blood pressure in order to compensate lowered cardiac output due to myocardial infarction. However, the adverse influence accompanying overactivation of sympathetic nerve would bring deteriorated outcome resulting from increased oxygen

Table 4 Independent factors associated with 30-day bleeding events by logistic regression analysis

Variables	OR (95% CI)	p Value
Age (per year)	1.033 (1.019 to 1.047)	<0.001
Weight (per kg)	0.983 (0.970 to 0.996)	0.014
Thrombolysis	2.310 (1.697 to 3.146)	<0.001
PCI	3.502 (2.065 to 5.938)	<0.001
Aspirin	1.846 (1.006 to 3.386)	0.048
Admission SBP (mm Hg)		
Normal SBP (100–139)	1 (reference)	
Modestly elevated SBP (140–179)	1.108 (0.677 to 1.816)	0.683
Excessively elevated SBP (≥ 180)	2.119 (0.746 to 6.013)	0.158

PCI, percutaneous coronary intervention; SBP, systolic blood pressure.

consumption, elevated chamber wall strain as well as facilitate arrhythmia.¹⁰ Therefore, blood pressure, a significant vital sign, obtained conveniently at admission, has been regarded as an important factor contributing to the prognosis of ACS and lower admission SBP was confirmed to relate with poor prognosis in several risk scores.^{3–5} However, regarding the prognostic value of elevated admission SBP, there are limited studies which reported conflicting results. A survey conducted by Jonas *et al*²¹ to evaluate the impact of excessively elevated admission blood pressure on the in-hospital management and course as well as 1-year outcome found that excessively elevated blood pressure (SBP >200 mm Hg or DBP >120 mm Hg) with acute myocardial infarction was not associated with a worse short-term or 1-year outcome. Furthermore, in the Greek Study of Acute Coronary Syndromes (GREECS),⁶ it was found that admission SBP was inversely related with in-hospital mortality and a 10 mm Hg increment in SBP was associated with a 27% decrease in the risk of in-hospital death, even the SBP >160 mm Hg also with a modest further reduction. Consistent with this result, data from the Registry of Information and Knowledge About Swedish Heart Intensive Care Admissions (RIKS-HIA)⁷ analysed the relationship between admission blood pressure and 1-year mortality in patients with chest pain and found

Table 3 Incidence of bleeding events according to the BARC definition stratified by admission SBP (mm_Hg)

	Normal SBP (100–139) (n=4182)	Modestly elevated SBP (140–179) (n=2187)	Excessively elevated SBP (≥ 180) (n=222)	p Value
Bleeding events within 7 days (n (%))				0.979
Type 1 and type 2	131 (3.1)	69 (3.2)	7 (3.2)	
Type 3	13 (0.3)	10 (0.5)	1 (0.5)	
Type 5	3 (0.1)	2 (0.1)	0 (0.0)	
Bleeding events within 30 days (n (%))				0.523
Type 1 and type 2	133 (3.2)	69 (3.2)	13 (5.9)	
Type 3	18 (0.4)	10 (0.5)	1 (0.5)	
Type 5	3 (0.1)	2 (0.1)	0 (0.0)	

BARC, bleeding academic research consortium; SBP, systolic blood pressure.

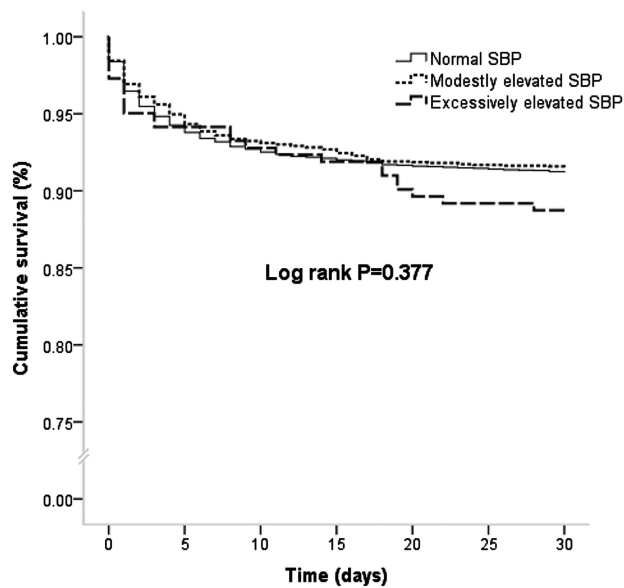


Figure 2 The Kaplan-Meier curves for survival stratified by admission SBP. SBP, systolic blood pressure.

there was an inverse association between admission SBP and 1-year mortality. However, a study of acute myocardial infarction from Japan reported that admission SBP 141–159 mm Hg was correlated with a better in-hospital prognosis, whereas admission SBP ≥ 160 mm Hg was not optimal and led to an increased incidence of cardiac rupture which might contribute in part to a relatively higher in-hospital mortality.⁸ Likewise, in patients with acute myocardial infarction undergoing PCI, similar conclusions were reached.⁹

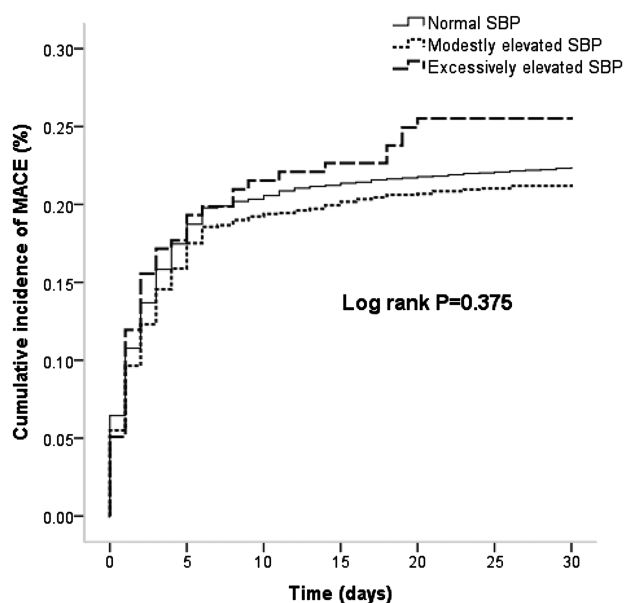


Figure 3 The curves for cumulative MACE stratified by admission SBP. MACE, major adverse cardiac events; SBP, systolic blood pressure.

Our results showed that those with elevated admission SBP after STEMI had a high-risk profile. They were more likely to be older, with a higher proportion of female gender and more likely to have concomitant cardiovascular morbidities. Meanwhile, higher heart rate, blood sugar and Killip class >1 at admission were found among these patients. In addition, more events of anterior myocardial infarction, less reperfusion treatment and anticoagulation therapy characterised these patients. The aforementioned characteristics were indicators of poor prognosis stratified by current guidelines and risk scores. However, they had comparable short-term mortality, incidence of MACE and bleeding, as well as risks related with short-term mortality and MACE after multivariate adjusting compared with those with normal admission SBP. It is noteworthy that several studies^{11 12 14 15} have reported that elevated admission SBP was associated with increased risk of bleeding events, especially when SBP exceeded 175 mm Hg. In contrast, our study showed that patients with excessively elevated SBP had similar incidence of bleeding compared with those with normal admission SBP. Besides, elevated admission SBP was not yet a risk factor for bleeding in multivariate logistic analysis. We inferred that ethnic heterogeneity and disparity in thrombolytic drugs used might account for the inconsistent conclusions.

In our study, it was found that the percentage of patients who received reperfusion treatment was low and was significantly different between the groups. Some possible interpretation should be inferred. This was a multicentre registry study and the medical institutions included in this study covered different levels of medical care (academic and non-academic, general and specialised, urban and rural). Disequilibrium of healthcare resulted in distinct treatment in these medical institutions, which led to a relatively low application of reperfusion in our study. Moreover, the decision to use reperfusion therapy was based on the evaluation that integrated the clinical features at presentation, patient comorbidities and use of medical resources as well as risk-benefit analysis, which disposed patients with STEMI with elevated admission SBP to receive less reperfusion treatment. Also, the standard medication therapy was inadequate such as relatively lower use of clopidogrel, β blockers and statins in our study. This was a real-world study and also reflected the huge gulf between clinical guidelines and real-world practice, and an improved condition was anticipated. Furthermore, we used multivariate Cox regression analysis to eliminate, to some extent, the effect of imbalance of baseline characteristics on the outcome. However, after multivariate adjustment, elevated admission SBP was not associated with increased risk of poor short-term outcome. The reason why those with elevated SBP despite having a higher risk at baseline, were not associated with a worse short-term outcome remains unclear. However, several possibilities might account for this phenomenon.

Table 5 Adjusted HRs according to the admission SBP (mm Hg)

	Normal SBP (100–139)	Modestly elevated SBP (140–179)	p Value	Excessively elevated SBP (≥ 180)	
	HR	HR (95% CI)		HR (95% CI)	p Value
All-cause mortality					
Within 7 days	1 (reference)	0.905 (0.698 to 1.175)	0.454	0.766 (0.408 to 1.440)	0.408
Within 30 days	1 (reference)	0.850 (0.681 to 1.060)	0.148	0.920 (0.566 to 1.495)	0.737
MACE					
Within 7 days	1 (reference)	0.926 (0.793 to 1.018)	0.328	0.918 (0.640 to 1.318)	0.644
Within 30 days	1 (reference)	0.906 (0.783 to 1.047)	0.182	0.936 (0.673 to 1.303)	0.696

MACE, major adverse cardiac events; SBP, systolic blood pressure.

First, as aforementioned, blood pressure level after myocardial infarction is determined by integrated cardiovascular system and neuroendocrine system. Higher admission blood pressure is a marker of preserved cardiac function due to a relatively small infarction area and a positive and effective response to stress. In fact, observational studies in acute heart failure also found that admission SBP was inversely associated with the short-term outcome.^{26–28} Therefore, studies from acute myocardial infarction and acute heart failure suggested that elevated blood pressure, in a pronounced stressful situation, was not always harmful, to the contrary, was a symbol of compensation function in good condition. Second, patients with excessively elevated admission SBP in our study had a high prevalence of hypertension (77.9%). The antihypertension drugs they usually took, such as ACEI and β blockers, were cardioprotective. Moreover, these medications were maintained after myocardial infarction, also helpful in improving outcomes by mechanisms of reducing myocardial oxygen consumption, suppressing remoulding and reducing the risk of sudden death. Similarly, in Abrignani *et al's* report,²⁹ it was found that patients with hypertension with first acute myocardial infarction had a better in-hospital outcome than that of normotensive patients. It was proposed that a less severe extension of infarction area, higher coronary perfusion from elevated DBP as well as abundant collateral circulation formation in patients with hypertension contributed to a better short-term outcome. However, as far as the impact of hypertension on the short-term and long-term outcomes in patients with STEMI is concerned, studies reached inconsistent conclusion. In the thrombolytic era, some studies^{30–31} found hypertension adversely affected the short-term and long-term outcomes, while others^{32–33} found no difference in patients with and without hypertension. In the era of mechanical revascularisation, several recent studies have evaluated the impact of hypertension on the short-term and long-term outcomes in patients with STEMI and reported similar conclusion. In Rembek *et al's* report,³⁴ no difference was observed in in-hospital mortality between hypertensive and normotensive patients. Parodi *et al's*³⁵ found the 5-year mortality in patients with and without hypertension was comparable;

however, patients with hypertension were at a higher risk of developing heart failure after STEMI. Lazzeri *et al's*³⁶ assessed the influence of hypertension on the short-term and long-term outcome in 560 patients with STEMI submitted to mechanical revascularisation and found that a history of hypertension had no effect on either short-term or long-term mortality. Similar results were also found in Cecchi *et al's* report.³⁷ The reason why hypertension has no significant influence on the outcome in patients with STEMI who undergo PCI may be multifactorial. One possible interpretation is that patients with hypertensive STEMI did not show a larger infarct size compared with normotensive patients, depicted by De Luca G *et al's* study.³⁸ Another possible explanation was the altered lifestyle and standard antihypertensive therapy after STEMI which controlled the main cardiovascular risk factors and resulted in a relatively fair outcome.³⁷ However, although hypertension appeared to have no impact on the outcome in patients with STEMI who underwent PCI, patients with hypertension showed an altered glucose response to stress, as indicated by a higher incidence of acute insulin resistance and higher admission glucose values, which has been demonstrated to be a risk factor for 1-year mortality in patients with STEMI who underwent PCI with estimated glomerular filtration rate ≥ 60 mL/min/m².³⁹ Our study also showed that patients with elevated admission SBP presented with higher admission blood sugar and after multivariate adjustment, higher admission blood sugar was an independent risk factor for short-term mortality (data not shown). In addition, in our study, the reperfusion treatment was mainly by means of thrombolysis, but comparisons of the effect of thrombolysis on the groups were lacking. Whether those with excessively elevated admission SBP benefited more from thrombolysis after lowering the blood pressure to a level appropriate for thrombolysis deserved further study.

It is noteworthy that although short-term outcomes were similar between patients with normal and elevated admission SBP, it was shown from the survival and MACE curves that patients with excessively elevated admission SBP had a trend towards increased mortality and incidence of MACE as time went on. Therefore, the impact of elevated admission SBP, especially for those

with excessively elevated admission SBP, on the long-term outcome needed to be studied by follow-up.

There are some limitations of our study. First, it is a retrospective observational study and causal relationship cannot be inferred. Owing to the insufficiency of guideline implementation, our results may not be generalisable to patients with STEMI undergoing reperfusion therapy and standard medications. Therefore, prospective studies with standard therapy are needed to confirm our results. Second, data about SBP were collected at admission only, whereas detailed treatment and blood pressure control levels during hospitalisation and after discharge that might relate to the prognosis were not available. Third, due to the retrospective study design, other data such as left ventricular mass, left ventricular ejection fraction, severity of the residual stenosis of the infarct-related coronary artery and biomarkers of myocardial necrosis that were valuable parameters for evaluating prognosis were lacking. In addition, the number of patients with excessively elevated admission SBP was relatively small and might limit the statistical power. Finally, the follow-up time in our study was short-term and a long-term follow-up is required to evaluate the long-term prognostic value of elevated admission SBP in patients with STEMI.

CONCLUSION

Although those with elevated admission SBP after STEMI were at high risk for cardiovascular events, they did not experience poorer short-term outcomes compared with those with normal admission SBP.

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REFERENCES

- Maseri A, Rebuzzi AG, Cianflone D. Need for a composite risk stratification of patients with unstable coronary syndromes tailored to clinical practice. *Circulation* 1997;96:4141–2.
- Cannon CP. Acute coronary syndromes: risk stratification and initial management. *Cardiol Clin* 2005;23:401–9.
- Fox KA, Dabbous OH, Goldberg RJ, *et al*. Prediction of risk of death and myocardial infarction in the six months after presentation with acute coronary syndrome: prospective multinational observational study (GRACE). *BMJ* 2006;333:1091.
- Boersma E, Pieper KS, Steyerberg EW, *et al*. Predictors of outcome in patients with acute coronary syndromes without persistent ST-segment elevation. Results from an international trial of 9461 patients. The PURSUIT Investigators. *Circulation* 2000;101:2557–67.
- 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;102:2031–7.
- Pitsavos C, Panagiotakos D, Zombolos S, *et al*. Systolic blood pressure on admission predicts in-hospital mortality among patients presenting with acute coronary syndromes: the Greek study of acute coronary syndromes. *J Clin Hypertens (Greenwich)* 2008;10:362–6.
- Stenstrand U, Wijkman M, Fredrikson M, *et al*. Association between admission supine systolic blood pressure and 1-year mortality in patients admitted to the intensive care unit for acute chest pain. *JAMA* 2010;303:1167–72.
- Shiraishi J, Kohno Y, Sawada T, *et al*. Systolic blood pressure at admission, clinical manifestations, and in-hospital outcomes in patients with acute myocardial infarction. *J Cardiol* 2011;58:54–60.
- Shiraishi J, Kohno Y, Sawada T, *et al*. Prognostic impact of systolic blood pressure at admission on in-hospital outcome after primary percutaneous coronary intervention for acute myocardial infarction. *J Cardiol* 2012;60:139–44.
- Cohn JN. Neuroendocrine activation after acute myocardial infarction. *Am J Cardiol* 1990;65:281–311.
- 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.
- Anderson JL, Karagounis L, Allen A, *et al*. Older age and elevated blood pressure are risk factors for intracerebral hemorrhage after thrombolysis. *Am J Cardiol* 1991;68:166–70.
- Chaitman BR, Thompson B, Wittry MD, *et al*. The use of tissue-type plasminogen activator for acute myocardial infarction in the elderly: results from thrombolysis in myocardial infarction phase I, open label studies and the thrombolysis in myocardial infarction phase II pilot study. The TIMI investigators. *J Am Coll Cardiol* 1989;14:1159–65.
- Gurwitz JH, Gore JM, Goldberg RJ, *et al*. Risk for intracranial hemorrhage after tissue plasminogen activator treatment for acute myocardial infarction. Participants in the National Registry of Myocardial Infarction 2. *Ann Intern Med* 1998;129:597–604.
- Brass LM, Lichtman JH, Wang Y, *et al*. Intracranial hemorrhage associated with thrombolytic therapy for elderly patients with acute myocardial infarction: results from the Cooperative Cardiovascular Project. *Stroke* 2000;31:1802–11.
- Huynh T, Cox JL, Massel D, *et al*. Predictors of intracranial hemorrhage with fibrinolytic therapy in unselected community patients: a report from the FASTRAK II project. *Am Heart J* 2004;148:86–91.
- Andersen K, Bregendahl M, Kaestel H, *et al*. Haematoma after coronary angiography and percutaneous coronary intervention via the femoral artery frequency and risk factors. *Eur J Cardiovasc Nurs* 2005;4:123–7.
- Pierre-Louis B, Aronow WS, Yoon JH, *et al*. Risk factors for major bleeding and for minor bleeding after percutaneous coronary intervention in 634 consecutive patients with acute coronary syndromes. *Am J Ther* 2010;17:e74–7.
- O'Gara PT, Kushner FG, Ascheim DD, *et al*. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation* 2013;127:529–55.
- Shamshad F, Kenchaiah S, Finn PV, *et al*. Fatal myocardial rupture after acute myocardial infarction complicated by heart failure, left ventricular dysfunction, or both: the VALSartan In Acute myocardial infarction Trial (VALIANT). *Am Heart J* 2010;160:145–51.
- 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;84:162–5.
- Mehran R, Rao SV, Bhatt DL, *et al*. Standardized bleeding definitions for cardiovascular clinical trials: a consensus report from the Bleeding Academic Research Consortium. *Circulation* 2011;123:2736–47.

23. Ceremuzynski L. Hormonal and metabolic reactions evoked by acute myocardial infarction. *Circ Res* 1981;48:767–76.
24. Graham LN, Smith PA, Stoker JB, *et al.* Sympathetic neural hyperactivity and its normalization following unstable angina and acute myocardial infarction. *Clin Sci (Lond)* 2004;106:605–11.
25. Jardine DL, Charles CJ, Ashton RK, *et al.* Increased cardiac sympathetic nerve activity following acute myocardial infarction in a sheep model. *J Physiol* 2005;565:325–33.
26. Guder G, Frantz S, Bauersachs J, *et al.* Reverse epidemiology in systolic and nonsystolic heart failure: cumulative prognostic benefit of classical cardiovascular risk factors. *Circ Heart Fail* 2009;2:563–71.
27. Vidan MT, Bueno H, Wang Y, *et al.* The relationship between systolic blood pressure on admission and mortality in older patients with heart failure. *Eur J Heart Fail* 2010;12:148–55.
28. Perez-Calvo JI, Montero-Perez-Barquero M, Camafort-Babkowski M, *et al.* Influence of admission blood pressure on mortality in patients with acute decompensated heart failure. *QJM* 2011;104:325–33.
29. Abrignani MG, Dominguez LJ, Biondo G, *et al.* In-hospital complications of acute myocardial infarction in hypertensive subjects. *Am J Hypertens* 2005;18:165–70.
30. 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 Sopravvivenza nell'Infarto Miocardico. *J Hypertens* 1996;14:743–50.
31. Rabkin SW, Mathewson FA, Tate RB. Prognosis after acute myocardial infarction: relation to blood pressure values before infarction in a prospective cardiovascular study. *Am J Cardiol* 1977;40:604–10.
32. Majahalme SK, Smith DE, Cooper JV, *et al.* Comparison of patients with acute coronary syndrome with and without systemic hypertension. *Am J Cardiol* 2003;92:258–63.
33. Ali I, Akman D, Bruun NE, *et al.* Importance of a history of hypertension for the prognosis after acute myocardial infarction—for the Bucindolol Evaluation in Acute myocardial infarction Trial (BEAT) study group. *Clin Cardiol* 2004;27:265–9.
34. Rembek M, Goch A, Goch J. The clinical course of acute ST-elevation myocardial infarction in patients with hypertension. *Kardiol Pol* 2010;68:157–63.
35. Parodi G, Carrabba N, Santoro GM, *et al.* Heart failure and left ventricular remodeling after reperfused acute myocardial infarction in patients with hypertension. *Hypertension* 2006;47:706–10.
36. Lazzeri C, Valente S, Chiostrì M, *et al.* Impact of hypertension on short- and long-term prognoses in patients with ST elevation myocardial infarction and without previously known diabetes. *Heart Vessels* 2012;27:370–6.
37. Cecchi E, D'Alfonso MG, Chiostrì 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 Prev* 2014;21:37–43.
38. De Luca G, Parodi G, Sciaga R, *et al.* Impact of hypertension on infarct size in ST elevation myocardial infarction patients undergoing primary angioplasty. *J Hypertens* 2013;31:2433–7.
39. Lazzeri C, Valente S, Chiostrì M, *et al.* Hyperglycemia, acute insulin resistance, and renal dysfunction in the early phase of ST-elevation myocardial infarction without previously known diabetes: impact on long-term prognosis. *Heart Vessels* Published Online First: 20 Oct 2013. doi: 10.1007/s00380-013-0429-8