Correlation of Pre- and In-Hospital Systolic Blood Pressure in Acute Heart Failure Patients and the Prognostic Implications
– Report From the Tokyo Cardiac Care Unit Network Emergency Medical Service Database –

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Background: Systolic blood pressure (SBP) is an important prognostic indicator for patients with acute heart failure (AHF). However, its changes and the effects in the different phases of the acute management process are not well known.

Methods and Results: The Tokyo CCU Network prospectively collects on-site information about AHF from emergency medical services (EMS) and the emergency room (ER). The association between in-hospital death and SBP at 2 different time points (on-site SBP [measured by EMS] and in-hospital SBP [measured at the ER; ER-SBP]) was analyzed. From 2010 to 2012, a total of 5,669 patients were registered and stratified into groups according to both their on-site SBP and ER-SBP: >160 mmHg; 100–160 mmHg; and <100 mmHg. In-hospital mortality rates increased when both on-site SBP and ER-SBP were low. After multivariate adjustment, both SBPs were inversely associated with in-hospital death. Notably, the risk for patients with ER-SBP of 100–160 mmHg (intermediate risk) differed according to their on-site SBP; those with on-site SBP <100 or 100–160 mmHg were at higher risk (OR, 7.39; 95% CI, 4.00–13.6 and OR, 2.73; 95% CI, 1.83–4.08, respectively [P<0.001 for both]) than patients with on-site SBP >160 mmHg.

Conclusions: Monitoring changes in SBP assisted risk stratification of AHF patients, particularly patients with intermediate ER-SBP measurements. (Circ J 2016; 80: 2473–2481)

Key Words: Acute heart failure; Blood pressure change; Emergency medical service; Risk stratification; Systolic blood pressure

A cute heart failure (AHF) is frequently encountered by personnel of the emergency medical service (EMS) and in the emergency room (ER), and it is associated with several million hospitalizations worldwide each year, high mortality and morbidity rates, and high costs.1,2 Despite the introduction of effective treatments for HF, 30-day mortality and readmission rates remain high,2 and its management, particularly in the acute phase, remains a challenge.
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Acute triage has not been thoroughly investigated. In the present study, we aimed to evaluate the associations between SBP measured at 2 time points (pre-hospital [on-site by the EMS staff] and in hospital [at the ER]) and the clinical outcomes of patients with AHF. Monitoring alterations in SBP may provide additional information for tailoring the initial treatment strategy during acute triage of these patients. Additionally, assessing the prognostic implications may improve our understanding of AHF.

Methods

Study Design

The design of the Tokyo CCU Network (TCN) database has been previously reported. Briefly, the TCN database is an ongoing multicenter registry that prospectively collects information from both EMS (Tokyo Metropolitan EMS) and investigators at participating hospitals on emergency admissions to acute cardiac facilities. Its aim is to describe the demographic and clinical characteristics of patients hospitalized with acute cardiovascular diseases. All patients admitted to cardiac care units (CCUs) whose information had been catalogued by the TCN were eligible for participation in the present study. By December 2015, 73 hospitals, serving a population of 1.3 million individuals in the metropolitan Tokyo area, were included in the TCN registry.

Each TCN hospital is accredited by the Metropolitan Tokyo Government and participates in the Tokyo citywide system of acute care (acute myocardial infarction, unstable angina, arrhythmia, AHF, aortic dissection, and pulmonary embolism). Written or oral informed consent was given in all cases by the patients, if appropriate, and/or by legal representative during their hospital admission according to the institution’s protocol. Both types of informed consent were approved by the TCN Scientific Committee, as the study did not identify individual patients. In addition, the TCN registry conducts an annual epidemiological survey supported by the Tokyo

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Flow chart for study of acute heart failure patients in metropolitan Tokyo. ER-SBP, systolic blood pressure measured on presentation to the emergency room.

![Figure 2](https://example.com/figure2.png)

**Figure 2.** Distribution of on-site SBP and SBP measured in the emergency room (ER-SBP). SBP, systolic blood pressure.
BP Change in AHF

The on-site SBP was defined as SBP measured by EMS on arrival at the scene. ER-SBP was defined as SBP assessed before the initiation of HF therapy. The distribution of SBP in the AHF patients is shown in Figure 2.

Outcomes and Definitions of Variables
In the present study, the primary outcome was all-cause in-hospital death. All AHF patients were diagnosed using variables estimated on admission using the Framingham criteria. The estimated glomerular filtration rate (eGFR) was calculated using serum creatinine levels and the Modification of Diet in Renal Disease study equation. Anemia was defined as hemoglobin level <13 g/dl for men and <12 g/dl for women, according to the World Health Organization criteria. When N-terminal pro-B-type natriuretic peptide (NT-proBNP) was measured instead of BNP, the NT-proBNP value was converted to the BNP values using an equation established in a previous study.

Statistical Analysis
Results are expressed as mean±standard deviation or median with interquartile range (IQR) for continuous variables and as percentages for categorical variables, as appropriate. Statistical comparisons were performed using analysis of variance or Kruskal-Wallis tests for continuous variables and the Pearson’s chi-squared test for categorical variables. Missing data were rare (<5%) for all variables, except for left ventricular ejection fraction (LVEF) (10.0%) and BNP levels (23.8%). Missing values were imputed as follows: (1) for variables pertaining to comorbidity and medical treatment during hospitalization, missing data were imputed to “no”; (2) for body mass index, missing values were imputed to the sex-specific median; (3) for LVEF, missing values were imputed to the median value of the entire cohort; and (4) for serum creatinine, missing values were imputed to the sex- and prior renal failure-specific

EMS in Japan and BP Measurement
In Japan, non-private municipal emergency operation systems provide EMS through 800 fire stations via dispatching centers. The paramedics, similar to those in the Western system, provide medical care at an advanced life support level, though they have some limitations (eg, they are unable to use non-invasive positive airway pressure ventilation [NIPPV] or to administer drugs to patients, except for adrenalin in the case of cardiopulmonary arrest). Pre-hospital SBP was measured on-site by the EMS team (on-site SBP), and the in-hospital SBP was measured in the emergency room (ER-SBP) by hospital triage staff. The on-site SBP was defined as SBP measured by EMS on arrival at the scene. ER-SBP was defined as SBP assessed before the initiation of HF therapy. The distribution of SBP in the AHF patients is shown in Figure 2.

Study Sample
For the present analysis, data for consecutive patients registered in the AHF dataset were extracted from the TCN database; patients presenting with acute coronary syndrome were registered in a separate dataset and were therefore not included in this analysis. We identified 6,232 AHF patients who were transferred via ambulance to a participating hospital between 2010 and 2012. Patients who presented with out-of-hospital cardiac arrest (n=90; 1.4%) and those with missing data for SBP measured in the ER (ER-SBP; n=473; 7.6%) were excluded. Their main clinical characteristics did not differ from those of the patients included in the final analysis, other than for ischemic etiology (30.1% vs. 21.1% in the excluded patients) and prior admissions for HF (31.9% vs. 15.6% in the excluded patients) (Table S1). Finally, data from 5,669 patients were analyzed in the present study (Figure 1).

In-hospital mortality rates according to SBP in the emergency room (ER-SBP) (A) and on-site SBP (B). SBP, systolic blood pressure.
medians.

We subdivided the patients by 20-mmHg strata of ER-SBP, and the distribution of in-hospital mortality rates was evaluated to determine whether the relationship was linear (Figure 3A). A similar presentation was prepared for the on-site SBP values (Figure 3B). Based on the patients’ mortality risk in the SBP groups, we categorized the patients into 9 groups by on-site SBP and ER-SBP: (1) low risk (mortality rate <5%), SBP >160 mmHg; (2) intermediate risk (mortality rate 5–15%), SBP 100–160 mmHg; and (3) high risk (mortality rate >15%), SBP <100 mmHg. We then evaluated the unadjusted and adjusted relationships between SBP and in-hospital deaths using logistic regression models. The multivariate model was adjusted for age, sex, prior admissions for HF, chronic obstructive pulmonary disease (COPD), cerebrovascular disease (CVD), atrial fibrillation (AF), anemia, eGFR, and LVEF using a logistic regression model with a backward step-down variable deletion, removing terms with P > 0.2. All probability values were 2-tailed, and P < 0.05 was considered to be statistically significant. All statistical analyses were performed with SPSS version 19.0 (SPSS Inc, Chicago, IL, USA).

### Results

#### Patients’ Characteristics

The baseline characteristics of the study patients based on ER-SBP are summarized in Table 1. The patients were predominantly male (56.7%), with an average age of 75.9 ± 12.3 years. Patients with both higher on-site SBP and ER-SBP had higher heart rates and worse respiratory conditions, as suggested by respiratory rates and oxygen saturation. Among the patients with ER-SBP <100 mmHg, prior admissions for HF, CVD, and AF were more frequent than in patients with ER-SBP >160 mmHg (all P < 0.001). Laboratory findings revealed lower hemoglobin levels, poorer renal function, and higher C-reactive protein and BNP levels in patients with ER-SBP.

### Table 1. AHF Patients’ Characteristics Based on SBP in the ER (ER-SBP)

<table>
<thead>
<tr>
<th>Variable</th>
<th>All patients (n=5,669)</th>
<th>SBP &gt;160 mmHg (n=2,142)</th>
<th>SBP 100–160 mmHg (n=3,090)</th>
<th>SBP &lt;100 mmHg (n=437)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, year</td>
<td>75.9±12.3</td>
<td>75.3±12.1</td>
<td>76.3±12.9</td>
<td>73.3±13.4</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male, %</td>
<td>56.7</td>
<td>58.5</td>
<td>55.7</td>
<td>55.9</td>
<td>0.133</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>22.3±4.3</td>
<td>22.9±4.4</td>
<td>22.0±4.3</td>
<td>21.1±3.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time from EMS call to ER arrival, min*</td>
<td>35 (26–47)</td>
<td>34 (27–46)</td>
<td>35 (26–46)</td>
<td>37 (27–50)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>EMS call to scene, min*</td>
<td>8 (6–10)</td>
<td>8 (6–10)</td>
<td>8 (6–10)</td>
<td>8 (6–10)</td>
<td>0.207</td>
</tr>
<tr>
<td>Scene time, min*</td>
<td>17 (13–23)</td>
<td>17 (14–23)</td>
<td>17 (13–22)</td>
<td>18 (14–24)</td>
<td>0.182</td>
</tr>
<tr>
<td>Transportation time, min*</td>
<td>10 (7–14)</td>
<td>9 (7–13)</td>
<td>10 (7–14)</td>
<td>11 (7–16)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Vital signs on-site</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>149±38</td>
<td>178±33</td>
<td>136±28</td>
<td>103±30</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>85±34</td>
<td>99±43</td>
<td>79±23</td>
<td>62±19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulse pressure, mmHg</td>
<td>65±36</td>
<td>79±45</td>
<td>58±25</td>
<td>43±19</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HR, beats/min</td>
<td>102±34</td>
<td>108±26</td>
<td>100±39</td>
<td>95±30</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Respiratory rate, /min</td>
<td>25±8</td>
<td>27±7</td>
<td>24±8</td>
<td>23±6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Oxygen saturation (SpO₂), %</td>
<td>91 (82–96)</td>
<td>88 (79–94)</td>
<td>92 (85–96)</td>
<td>94 (86–97)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Vital signs at the ER</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>151±39</td>
<td>191±25</td>
<td>133±17</td>
<td>86±12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>86±25</td>
<td>105±24</td>
<td>78±17</td>
<td>54±12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulse pressure, mmHg</td>
<td>65±27</td>
<td>87±25</td>
<td>55±18</td>
<td>33±12</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart rate, beats/min</td>
<td>102±28</td>
<td>109±28</td>
<td>98±27</td>
<td>94±29</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Respiratory rate, /min</td>
<td>25±8</td>
<td>28±8</td>
<td>24±8</td>
<td>23±8</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Oxygen saturation (SpO₂), %</td>
<td>96 (91–98)</td>
<td>95 (90–98)</td>
<td>96 (93–99)</td>
<td>97 (93–99)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Comorbidities, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ischemic etiology</td>
<td>30.1</td>
<td>28.5</td>
<td>31.4</td>
<td>28.0</td>
<td>0.055</td>
</tr>
<tr>
<td>Prior admissions for HF</td>
<td>31.9</td>
<td>26.4</td>
<td>33.0</td>
<td>47.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension</td>
<td>61.9</td>
<td>72.5</td>
<td>58.2</td>
<td>42.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diabetes</td>
<td>32.4</td>
<td>34.4</td>
<td>31.7</td>
<td>29.4</td>
<td>0.048</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>23.3</td>
<td>24.9</td>
<td>23.1</td>
<td>18.5</td>
<td>0.012</td>
</tr>
<tr>
<td>CVD</td>
<td>10.4</td>
<td>9.0</td>
<td>10.7</td>
<td>13.8</td>
<td>0.007</td>
</tr>
<tr>
<td>COPD</td>
<td>6.2</td>
<td>5.3</td>
<td>6.7</td>
<td>6.7</td>
<td>0.131</td>
</tr>
<tr>
<td>AF</td>
<td>31.6</td>
<td>24.8</td>
<td>34.4</td>
<td>40.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Laboratory findings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemoglobin, g/dl</td>
<td>11.9±3.1</td>
<td>12.2±3.9</td>
<td>11.7±2.5</td>
<td>11.3±2.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum creatinine, g/dl</td>
<td>1.10 (0.80–1.70)</td>
<td>1.10 (0.81–1.70)</td>
<td>1.10 (0.81–1.61)</td>
<td>1.33 (0.96–2.10)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>C-reactive protein, g/dl</td>
<td>0.70 (0.20–2.40)</td>
<td>0.50 (0.19–1.58)</td>
<td>0.83 (0.30–3.00)</td>
<td>1.30 (0.30–4.30)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BNP, pg/ml†</td>
<td>768 (386–1,447)</td>
<td>745 (375–1,364)</td>
<td>768 (387–1,477)</td>
<td>899 (440–1,623)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LVEF, %</td>
<td>43±16</td>
<td>45±15</td>
<td>42±17</td>
<td>37±18</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

(Table 1 continued the next page.)
BP Change in AHF

tor blockers (ARB) and β-blockers (BB); either ACEI/ARB or BB were more frequently prescribed in patients with ER-SBP >160 mmHg (P<0.001 and 0.004, respectively).

SBP and In-Hospital Deaths

Overall, 432 (7.7%) patients died during hospitalization (64 [3.0%] in the ER-SBP >160 mmHg group; 274 [8.9%] in the ER-SBP 100–160 mmHg group; and 94 [21.5%] in the ER-SBP <100 mmHg group), with a lower ER-SBP being significantly associated with increased in-hospital mortality rates in the univariate logistic regression analysis (odds ratio [OR] for each 10-mmHg increment, 0.83; 95% confidence interval [CI], 0.80–0.85; P<0.001). Similarly, on-site SBP was also signifi-
in-hospital death in the low ER-SBP (<100 mmHg) subgroup. We further stratified the patients into 9 groups based on the combination of on-site SBP with ER-SBP and evaluated the in-hospital mortality rates (Figure 4). After multivariate adjustment for age, sex, and other significant variables (Table 2), on-site SBP remained associated with in-hospital death, particularly in patients with ER-SBP between 100 and 160 mmHg (Figure 5).

Among the patients with ER-SBP ranging from 100 to 160 mmHg, the on-site SBP was independently associated with in-hospital death, even after adjustment for age, prior admissions for heart failure, cerebrovascular disease, chronic obstructive pulmonary disease, anemia, estimated glomerular filtration rate, and left ventricular ejection fraction. CI, confidence interval; SBP, systolic blood pressure.

Table 2. Covariates Other Than SBP in a Logistic Regression Analysis for In-Hospital Death of AHF Patients

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Univariate analysis</th>
<th>Multivariate analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>P value</td>
</tr>
<tr>
<td>Age (1-year increments)</td>
<td>1.04 (1.03–1.05)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female</td>
<td>1.20 (0.99–1.46)</td>
<td>0.069</td>
</tr>
<tr>
<td>Prior admissions for HF</td>
<td>1.61 (1.32–1.97)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>CVD</td>
<td>1.50 (1.12–2.00)</td>
<td>0.006</td>
</tr>
<tr>
<td>COPD</td>
<td>2.15 (1.55–2.98)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>AF</td>
<td>1.20 (0.98–1.48)</td>
<td>0.083</td>
</tr>
<tr>
<td>Anemia</td>
<td>1.96 (1.57–2.46)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>eGFR (1 ml/min/1.73 m² decrements)</td>
<td>0.98 (0.98–0.99)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LVEF</td>
<td>0.99 (0.99–1.00)</td>
<td>0.070</td>
</tr>
</tbody>
</table>

CI, confidence interval; eGFR, estimated glomerular filtration rate; OR, odds ratio. Other abbreviations as in Table 1.

Figure 5. Forrest plots. Among patients with ER-SBP ranging from 100 to 160 mmHg, the on-site SBP was independently associated with in-hospital death, even after adjustment for age, prior admissions for heart failure, cerebrovascular disease, chronic obstructive pulmonary disease, anemia, estimated glomerular filtration rate, and left ventricular ejection fraction. CI, confidence interval; SBP, systolic blood pressure.

significantly associated with in-hospital mortality (OR for each 10-mmHg increment, 0.81; 95% CI, 0.78–0.83; P<0.001).

We then evaluated the prognostic value of on-site SBP within the 3 subgroups stratified by ER-SBP (<100, 100–160, and >160 mmHg). Among the patients with intermediate ER-SBP (100–160 mmHg), on-site SBP was significantly and linearly associated with in-hospital death (OR for each 10-mmHg increment, 0.83; 95% CI, 0.79–0.88; P<0.001). On-site SBP also showed a similar association in patients with high ER-SBP (>160 mmHg), but the relationship was not linear, but spline. There was no association between on-site SBP and in-hospital death in the low ER-SBP (<100 mmHg) subgroup.

We further stratified the patients into 9 groups based on the combination of on-site SBP with ER-SBP and evaluated the in-hospital mortality rates (Figure 4). After multivariate adjustment for age, sex, and other significant variables (Table 2), on-site SBP remained associated with in-hospital death, particularly in patients with ER-SBP between 100 and 160 mmHg (Figure 5).
function was noted for patients with on-site SBP <100 mmHg (Table S2). We also constructed an additional model including BNP level as a covariate, for there was a significant difference in its value among the 3 ER-SBP subgroups. Although there were a modest number of patients without BNP measurement data at the time of admission (23.8%), on-site SBP remained a significant predictor of in-hospital death within the intermediate ER-SBP subgroup (Table S3).

Discussion

In the present AHF dataset, constructed in collaboration with EMS and CCU services in metropolitan Tokyo, both the on-site SBP and the ER-SBP were powerful prognostic indicators for patients with AHF. Measuring the change in SBP while patients were in the acute setting enabled us to precisely discriminate those at high or low risk. Specifically, among patients with ER-SBP between 100 and 160 mmHg, on-site SBP added an additional value for predicting in-hospital death, even after adjustment for known predictors. To our knowledge, this is the first study to investigate the relationship of the change in SBP during patient stay with HF, to the same extent in both the acute and chronic phases.

SBP is a well-known powerful prognostic indicator in patients with HF, to the same extent in both the acute and chronic phases. SBP is included in several risk stratification models for HF recommended in the ACCF/AHA guideline for the management of heart failure, the Acute Decompensated Heart Failure National Registry (ADHERE) risk tree, the Get-With-The-Guideline Heart Failure (GWTF-HF) Model, and the Seattle Heart Failure Model (SHFM). Ambrosy et al previously demonstrated, from the Efficacy of Vasopressin Antagonism in Heart Failure (EVEREST) trial, that both the SBP after initial HF therapy during hospitalization and the SBP at discharge were independent clinical predictors of morbidity and mortality in patients hospitalized for AHF. To date, the clinical significance of the change in SBP during acute management of AHF has been understudied.

Unlike the previous study, our study focused less on the absolute change in SBP, as a result of the response to treatment, by nature of the study’s design. In the present study, pre-hospital intervention for AHF patients was oxygenation only; neither drugs nor NIPPV was used. Therefore, our results indicate that the monitoring of changes in SBP itself is important for AHF patients as part of the natural course, rather than during medical intervention in the pre-hospital phase or during hospitalization. The change in SBP from pre-hospital to ER triage can provide new insights into the natural history of early AHF, and acute cardiopulmonary edema. Although the results of the present study demonstrated that the time interval between the EMS call and ER arrival was relatively short (median, 35 min) and subsequently that advanced treatment in the ER begins early in the metropolitan Tokyo area, the on-site SBP is more important in rural regions, where it takes much longer to transfer patients to hospital.

As our results described, several important differences were observed among patients with ER-SBP between 100 and 160 mmHg. These factors are known to be associated with prognosis in patients with HF: prior admissions for HF, anemia, and BNP level. In particular, renal impairment is a powerful prognostic factor in patients with AHF. In addition, Mitsnefes et al have reported that patients with chronic renal impairment, particularly those on dialysis, have significantly low contractile reserve. In the present analysis, our results indicated that a change in SBP during patient stay in the acute setting was not associated with renal function or other factors, although a change in SBP itself does not reflect cardiac contractile reserve; therefore, SBP change should be considered a useful clinical predictor in patients with AHF.

EMS systems are different in each country or can also vary within regions of the same country, with respect to the expertise of paramedics, availability of diagnostic and therapeutic equipment, and ability to administer drugs. In Japan, paramedics have several limitations, including the inability to use NIPPV and to administer drugs, except for adrenalin in the case of cardiopulmonary arrest. As our results demonstrated that on-site SBP was associated with the in-hospital death of AHF patients, early treatment initiation, such as fluid infusion, should be considered to improve prognosis, especially among high-risk patients presenting with hypotension and hypoperfusion. Patients in a critical condition may even benefit from administration of pre-hospital drugs during EMS transfer. Hemodynamic improvement has been an important target in contemporary AHF therapy, although little evidence exists in this area. Paramedics with sufficient training for HF care and with the ability to provide appropriate management under physicians’ control may be needed to accurately assess the benefit of these interventions.

Study Limitations

The present study using the TCN database was limited by several factors. First, the data were obtained from an observational study, and unmeasured factors may have influenced the clinical outcomes. We had no information regarding ER management. Furthermore, there were substantial numbers of patients who did not have their BNP level measured at the time of hospital admission. It is possible that patients with typical AHF symptoms frequently do not have BNP measured, and this may lead to bias on the predictive value of SBP. Second, this registry is geographically limited to the metropolitan Tokyo area, where there is a dense network of hospitals and EMS.

Conclusions

In our study, both on-site SBP and ER-SBP were independent predictors in patients with AHF; in particular, among patients with ER-SBP between 100 and 160 mmHg, on-site SBP provided an additional value for identifying high-risk patients. Monitoring alterations in SBP aided the stratification of AHF patients by risk.

Acknowledgments

We thank Ms Nobuko Yoshida, and other staff of the Tokyo CCU Network Scientific Committee for their important contributions.

Conflict of Interest

The authors have stated that no such relationships exist and provide the following details: S.K. received lecture fees from Pfizer Japan Inc, and an unrestricted research grant for the Department of Cardiology, Keio University School of Medicine from Bayer Pharmaceutical Co, Ltd. Other authors have no conflicts of interest to disclose. There are no patents, products in development or marketed products to declare.

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References


Discussion

In the present AHF dataset, constructed in collaboration with EMS and CCU services in metropolitan Tokyo, both the on-site SBP and the ER-SBP were powerful prognostic indicators for patients with AHF. Measuring the change in SBP while patients were in the acute setting enabled us to precisely discriminate those at high or low risk. Specifically, among patients with ER-SBP between 100 and 160 mmHg, on-site SBP added an additional value for predicting in-hospital death, even after adjustment for known predictors. To our knowledge, this is the first study to investigate the relationship of the change in SBP during patient stay with HF, to the same extent in both the acute and chronic phases. SBP is a well-known powerful prognostic indicator in patients with HF, to the same extent in both the acute and chronic phases. SBP is included in several risk stratification models for HF recommended in the ACCF/AHA guideline for the management of heart failure, the Acute Decompensated Heart Failure National Registry (ADHERE) risk tree, the Get-With-The-Guideline Heart Failure (GWTF-HF) Model, and the Seattle Heart Failure Model (SHFM). Ambrosy et al previously demonstrated, from the Efficacy of Vasopressin Antagonism in Heart Failure (EVEREST) trial, that both the SBP after initial HF therapy during hospitalization and the SBP at discharge were independent clinical predictors of morbidity and mortality in patients hospitalized for AHF. To date, the clinical significance of the change in SBP during acute management of AHF has been understudied.

Unlike the previous study, our study focused less on the absolute change in SBP, as a result of the response to treatment, by nature of the study’s design. In the present study, pre-hospital intervention for AHF patients was oxygenation only; neither drugs nor NIPPV was used. Therefore, our results indicate that the monitoring of changes in SBP itself is important for AHF patients as part of the natural course, rather than during medical intervention in the pre-hospital phase or during hospitalization. The change in SBP from pre-hospital to ER triage can provide new insights into the natural history of early AHF, and acute cardiopulmonary edema. Although the results of the present study demonstrated that the time interval between the EMS call and ER arrival was relatively short (median, 35 min) and subsequently that advanced treatment in the ER begins early in the metropolitan Tokyo area, the on-site SBP is more important in rural regions, where it takes much longer to transfer patients to hospital.

As our results described, several important differences were observed among patients with ER-SBP between 100 and 160 mmHg. These factors are known to be associated with prognosis in patients with HF: prior admissions for HF, anemia, and BNP level. In particular, renal impairment is a powerful prognostic factor in patients with AHF. In addition, Mitsnefes et al have reported that patients with chronic renal impairment, particularly those on dialysis, have significantly low contractile reserve. In the present analysis, our results indicated that a change in SBP during patient stay in the acute setting was not associated with renal function or other factors, although a change in SBP itself does not reflect cardiac contractile reserve; therefore, SBP change should be considered a useful clinical predictor in patients with AHF.

EMS systems are different in each country or can also vary within regions of the same country, with respect to the expertise of paramedics, availability of diagnostic and therapeutic equipment, and ability to administer drugs. In Japan, paramedics have several limitations, including the inability to use NIPPV and to administer drugs, except for adrenalin in the case of cardiopulmonary arrest. As our results demonstrated that on-site SBP was associated with the in-hospital death of AHF patients, early treatment initiation, such as fluid infusion, should be considered to improve prognosis, especially among high-risk patients presenting with hypotension and hypoperfusion. Patients in a critical condition may even benefit from administration of pre-hospital drugs during EMS transfer. Hemodynamic improvement has been an important target in contemporary AHF therapy, although little evidence exists in this area. Paramedics with sufficient training for HF care and with the ability to provide appropriate management under physicians’ control may be needed to accurately assess the benefit of these interventions.

Study Limitations

The present study using the TCN database was limited by several factors. First, the data were obtained from an observational study, and unmeasured factors may have influenced the clinical outcomes. We had no information regarding ER management. Furthermore, there were substantial numbers of patients who did not have their BNP level measured at the time of hospital admission. It is possible that patients with typical AHF symptoms frequently do not have BNP measured, and this may lead to bias on the predictive value of SBP. Second, this registry is geographically limited to the metropolitan Tokyo area, where there is a dense network of hospitals and EMS.

Conclusions

In our study, both on-site SBP and ER-SBP were independent predictors in patients with AHF; in particular, among patients with ER-SBP between 100 and 160 mmHg, on-site SBP provided an additional value for identifying high-risk patients. Monitoring alterations in SBP aided the stratification of AHF patients by risk.

Acknowledgments

We thank Ms Nobuko Yoshida, and other staff of the Tokyo CCU Network Scientific Committee for their important contributions.

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References


Appendix 2

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Supplementary Files

Table S1. Characteristics of included and excluded patients in a study of AHF
Table S2. Characteristics of the AHF patients with ER-SBP ranging from 100 to 160 mmHg according to on-site SBP
Table S3. Covariates of logistic regression model including BNP in a study of AHF

Please find supplementary file(s):