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Original Article

Comparison of baseline investigations and hospital mortality among ICU patients with heart failure between the public MIMIC-II database and Chinese PLA general hospital

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Abstract: *Background/Aim:* Heart failure is a complex clinical syndrome with high prevalence and mortality rates worldwide. Comparison of studies between countries may facilitate improvements in therapy and prognosis of heart failure (HF). We aimed to determine the differences in risk factors for hospital death of patients with HF admitted to the Intensive Care Units (ICU) of the Beth Israel Deacons Medical Center (BIDMC) and Chinese PLA General Hospital (PLAGH) by comparing hospital mortality rates and baseline investigations between the public Multiparameter Intelligent Monitoring in Intensive Care (MIMIC) II database and PLAGH. *Methods:* We selected 2439 ICU patients hospitalized for HF from the MIMIC-II database and 637 patients from PLAGH for comparison of creatinine and urea nitrogen (UN) levels. Any-cause hospital mortality and 18 diagnostic parameters (creatinine, UN, glucose, pH, cTroponinT, uric acid, calcium, cholesterol, triglyceride, total protein, albumin, partial pressure of oxygen (PO_2), partial pressure of carbon dioxide (PCO_2), red blood cell (RBC) count, chloride, potassium, amino terminal B-type natriuretic peptide (NT-proBNP), sodium) examined in both hospitals were compared between BIDMC and PLAGH using Mann-Whitney U or chi-squared test. Multivariate binary logistic regression analysis was used to select indexes that differed significantly between patients that died in hospital and dischargers. *Results:* No significant differences in any-cause hospital mortality were evident between the two hospitals (P=0.091). In the Mann-Whitney U test, baseline median age, UN, pH, cTroponinT, chloride, potassium, PO_2, PCO_2 and NT-proBNP levels were higher while RBC, uric acid, calcium, total protein, albumin and cholesterol were lower in patients from MIMIC-II compared to PLAGH. Age, serum cTroponinT and albumin in both hospitals, in addition to serum creatinine, urea nitrogen, glucose, pH, RBC, calcium, potassium, sodium, PCO_2 and cholesterol in MIMIC-II as well as total protein and NT-proBNP in PLAGH were statistical different between patients that died in hospital and those discharged, respectively. Further, age and albumin in both hospitals, moreover serum urea nitrogen, glucose, pH and potassium in BIDMC and serum cTroponinT in PLAGH were associated with hospital mortality. *Conclusions:* Comprehensive studies comparing laboratory parameters and mortality in ICU patients from teaching hospitals between the USA and China may facilitate effective HF prognosis and identification of risk factors of mortality. Similar hospital mortality rates of ICU patients with HF were observed between BIDMC and PLAGH. Our findings may contribute to the evaluation and establishment of effective prognostic and risk factors for hospital mortality in ICU patients with HF.

Keywords: Laboratory investigations, heart failure, hospital mortality rates, intensive care unit, MIMIC

Introduction

Heart failure (HF) is a complex clinical syndrome presenting with breathlessness symptoms and pulmonary crackles signs originating from the abnormalities in cardiac structure or function [1]. Data from the National Health and Nutrition Examination Survey obtained between

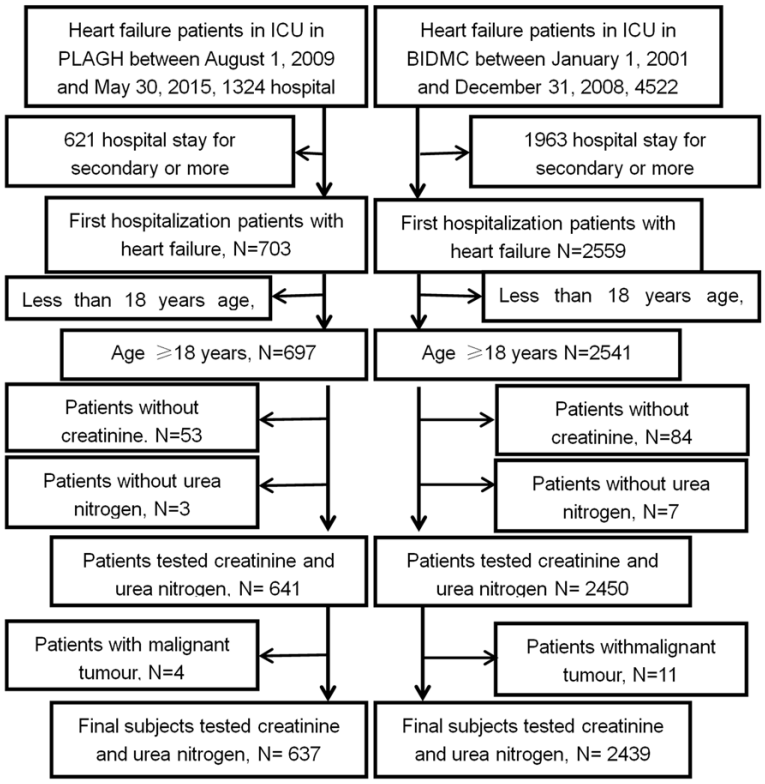

Figure 1. Study population attrition. Abbreviations: ICU, intensive care unit; BIDMC, Beth Israel Deaconess Medical Center; PLAGH, People's Liberation Army General Hospital.

2009 and 2012 indicate a prevalence of HF of about 5.7 million, which is estimated to increase by 46% from 2012 to 2030 to include >8 million Americans ≥20 years of age [2]. A representative 1%-2% of the adult population suffers from congestive heart failure (CHF) in developed countries, with the prevalence increasing to ≥10% among individuals aged ≥70 years [1]. The incidence of HF was reported to have reached about 4.5 million in China by the end of 2013.

While several research groups have focused on the treatment of HF, limited studies have compared the intensive care unit (ICU) admission rates and outcomes of patients between countries. Among the documented studies, Lai *et al.* [3] compared the admission rates and outcomes of acute decompensated HF (ADHF) patients between the emergency department of a Canadian and a U.S. hospital. Hossain and co-workers [4] showed similar mortality rates among very preterm neonatal ICU infants born within tertiary centers in Canada, Australia and New Zealand.

To our knowledge, several comparative reports between the USA and China have been published [5, 6], but no previous studies have compared the routine admission laboratory tests and outcomes for patients with HF between teaching hospitals. Our findings may help to fill this gap in knowledge. We hypothesized that patient outcomes are not significantly different between the two hospitals, while the risk factors for hospital mortality differ.

Methods

Study population

The Multiparameter Intelligent Monitoring in Intensive Care (MIMIC) II [7] database (http://physionet.org/mimic2/) includes all patients admitted to ICU at the Beth Israel Deacons Medical Center (BIDMC) [8] since 2001 (Boston, MA, USA). In this study, we included all consecutive adult patients (aged >18 years) with HF admitted to ICU in MIMIC-II (2001-2008) and PLA general hospital (PLAGH, August, 2009-May, 2015). Only the first hospitalization and ICU record for each patient was analyzed during the observation period. Patients with malignant tumors were excluded. Selection criteria of patients for analysis are presented in **Figure 1**. In total, 2439 patients from MIMIC-II and 637 from PLAGH were selected. Our study conformed to the principles outlined in the Declaration of Helsinki and was approved by PLAGH's Ethics Committee.

Data collection

For this retrospective study, patient's data excluding private information were extracted from PLAGH Information System (including 372 laboratory investigations) and the MIMIC-II database, version 26 (including 622 investigations). Overall, 148 diagnostic parameters were matched between the databases, among which 18 (creatinine, urea nitrogen (UN), glucose, pH, cTroponinT, uric acid, calcium, cholesterol, tri-

Table 1. Conversion coefficient (CC) between USA and international system (IS) of units

Investigations	USA unit	CC	IS unit
Creatinine	mg/dL	88.402	μmol/L
Urea Nitrogen	mg/dL	0.357	mmol/L
Glucose	mg/dL	0.05551	mmol/L
cTroponinT	mg/dL	10	ng/ml
Uric Acid	mg/dL	59.48	μmol/L
Chloride	mEq/L	1	mmol/L
Calcium	mg/dL	0.2495	mmol/L
Potassium	mEq/L	1	mmol/L
Sodium	mEq/L	1	mmol/L
Total Protein	g/dL	10	g/L
Albumin	g/dL	10	g/L
Cholesterol	mg/dL	0.02586	mmol/L
Triglyceride	mg/dL	0.01129	mmol/L

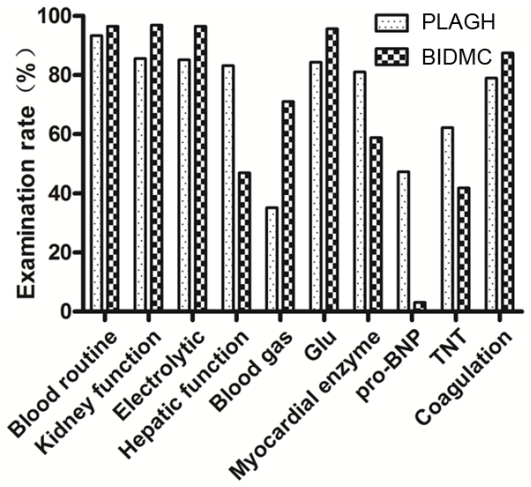

Figure 2. Different examination rates of laboratory tests between BIDMC and PLAGH. Abbreviations: BIDMC, Beth Israel Deaconess Medical Center; PLAGH, People's Liberation Army General Hospital; UN, urea nitrogen.

glyceride, total protein, albumin, partial pressure of oxygen (PO_2), partial pressure of carbon dioxide (PCO_2), chloride, red blood cells (RBC) count, potassium, amino terminal B-type natriuretic peptide (NT-proBNP) and sodium) were analyzed in view of the ≥60% examination rates in either hospital (except total protein, uric acid and NT-proBNP). We converted indexes in MIMIC-II measured in USA units to international system (IS) units, as shown in **Table 1**. Converted digits were rounded to retain significant fractions. Then the 18 investigations were further evaluated, among which creatinine and UN were for all patients.

Endpoints

The outcome measurement was any-cause hospital death or discharge. Baseline laboratory measurements were defined as indexes measured within the first 24 h after ICU. The primary objective of the study was to investigate the differences in outcomes of ICU heart failure patients between BIDMC and PLAGH.

Statistical analysis

Continuous variables with skewed distribution were expressed as median and interquartile range, and categorical variables as absolute numbers and percentages. Baseline laboratory indexes and outcomes were evaluated using the Mann Whitney U test for continuous variables, and chi-squared test for categorical variables. Multivariate binary logistic analysis was utilized to select significant different indexes and determine the relevance between two groups. The level of significance for all analyses was set at $P<0.05$, using two-tailed comparisons, and not altered when multiple comparisons were performed. SPSS for Windows statistical software (version 19.0.0.1, SPSS Inc., Chicago, IL, USA) was employed for all data analyses.

Results

Overall, 148 matched laboratory examinations were prescribed for ICU patients ≥18 years of age with HF between BIDMC and PLAGH, which mainly included the routine blood, myocardial enzyme, renal function, liver function, electrolyte, glucose, and coagulation tests in blood. The major difference was that PLAGH doctors tended to prescribe liver function, cTroponinT, NT-proBNP and myocardial enzyme tests, while BIDMC doctors preferred the blood gas test (**Figure 2**).

Annual distribution of admission times of patients with HF in ICUs of BIDMC and PLAGH was evaluated (**Figure 3**). Annual admission rates were relatively average over all the months in BIDMC, while in PLAGH, the hospitalization rate was decreased in July, relative to other months.

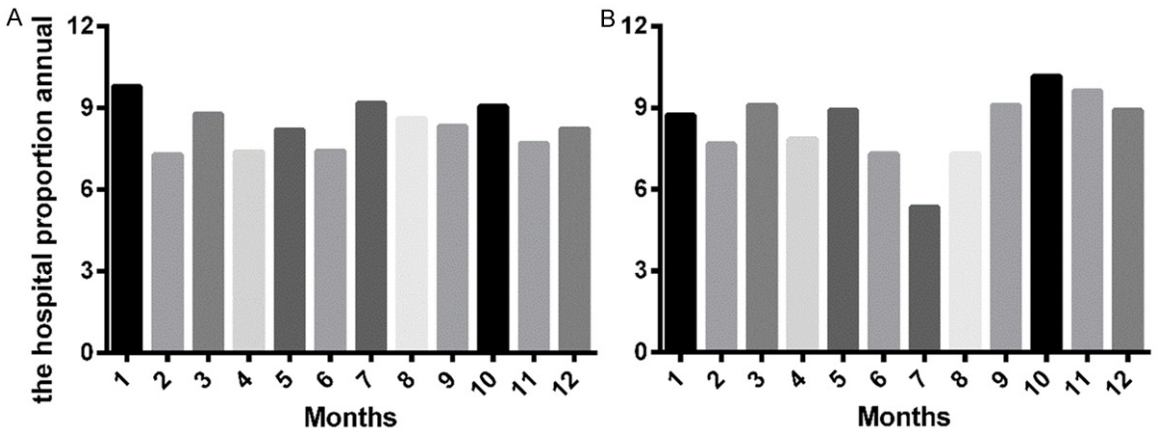

Figure 3. Monthly distribution of ICU inpatients over the year in the two hospitals (%). A: Distribution in BIDMC; B: Distribution in PLAGH. Abbreviations: ICU, intensive care unit; BIDMC, Beth Israel Deaconess Medical Center; PLAGH, People's Liberation Army General Hospital.

Table 2. Baseline investigations and outcomes of ICU patients with heart failure in BIDMC and PLAGH

	BIDMC (2439)	PLAGH (637)	*P*
Hospitalmortality (%)	343 (14.1%) (2439)	73 (11.5%) (637)	0.091
Male (%)	1299 (53.3%) (2439)	358 (56.2%) (637)	0.196
Age (year)	74.0 (62.7 81.9) (2439)	66.0 (55.0 74.0) (637)	<0.001
Creatinine (μmol/L)	97.2 (70.7 150.3) (2439)	89.6 (70.3 132.1) (637)	0.252
UN (mmol/L)	9.64 (6.43 15.35) (2439)	7.80 (5.81 11.92) (637)	<0.001
Glucose (mmol/L)	6.55 (5.50 7.99) (2410)	6.22 (5.07 8.51) (634)	0.134
pH	7.40 (7.36 7.44) (1815)	7.39 (7.36 7.43) (250)	0.015
cTropnT (ng/ml)	0.800 (0.100 4.475) (1044)	0.047 (0.017 0.246) (515)	<0.001
RBC ($\times 10^{12}$/L)	3.44 (3.14 3.82) (2420)	4.05 (3.42 4.55) (629)	<0.001
Uric Acid (μmol/L)	350.9 (208.2 514.5) (145)	380.2 (289.9 481.0) (628)	0.047
Chloride (mmol/L)	104.0 (100.0 107.0) (2425)	103.5 (100.0 106.3) (634)	0.005
Calcium (mmol/L)	2.10 (2.00 2.20) (2227)	2.17 (2.07 2.28) (628)	<0.001
Potassium (mmol/L)	4.10 (3.80 4.40) (2423)	4.01 (3.65 4.39) (636)	0.006
Sodium (mmol/L)	139.0 (136.0 142.0) (2423)	139.6 (136.7 142.0) (635)	0.469
Total Protein (g/L)	55.0 (48.5 61.5) (117)	65.3 (59.7 70.7) (627)	<0.001
Albumin (g/L)	29.0 (25.0 33.0) (1125)	35.8 (31.7 39.6) (581)	<0.001
PO_2 (mm Hg)	94.0 (76.0 124.0) (1780)	77.7 (66.4 97.7) (250)	<0.001
PCO_2 (mm Hg)	41.0 (36.0 47.0) (1780)	36.4 (32.3 42.0) (250)	<0.001
Cholesterol (mmol/L)	3.75 (3.00 4.67) (300)	3.98 (3.29 4.84) (520)	0.004
Triglyceride (mmol/L)	1.25 (0.87 1.76) (377)	1.18 (0.83 1.75) (519)	0.258
NT-proBNP (pg/mL)	6793 (2791 14834) (77)	4387 (1407 11580) (483)	0.011

Baseline characteristics are expressed as medians (interquartile) (N) or absolute value (percentages, %) (N), and N represents samples sizes for every baseline characteristicwith non-missing data. For example, baseline glucose includes 2410 of the 2439 BIDMC patients and 634 of the 637 PLAGH patients. Abbreviations: ICU, intensive care unit; BIDMC, Beth Israel Deaconess Medical Center; PLAGH, People's Liberation Army General Hospital; UN, Urea Nitrogen; RBC, red blood cell; NT-proBNP, amino terminal B-type natriuretic peptide.

Baseline investigations and outcomes of patients with HF admitted to ICU were compared between BIDMC and PLAGH (**Table 2**). Any-cause mortality rate during hospitalization in BIDMC was slightly higher than that in PLAGH, although this difference was not statistically significant. Baseline median age, UN, pH, cTroponinT, chloride, potassium, PO_2, PCO_2 and

Table 3. Comparison of baseline investigations of ICU patients that died from all-causes in hospital with dischargers in BIDMC and PLAGH

	BIDMC (N=2439)		*P*	GLAPH (N=637)		*P*
	Dead in hospital (N=343)	Discharge (N=2096)		Dead in hospital (N=73)	Discharge (N=564)	
Male (%)	181 (52.8%)	1118 (53.3%)	0.844	40 (54.8%)	318 (56.4%)	0.803
Age (year)	78.7 (69.2 85.1) (343)*	73.3 (61.7 81.4) (2096)	<0.001	73 (61.5 79.0) (73)	65.0 (54.0 74.0) (564)	0.001
Creatinine (μmol/L)	141.4 (88.4 247.5) (343)*	88.4 (70.7 132.6) (2096)	<0.001	98.4 (75.8 143.0) (73)	88.5 (69.7 129.9) (564)	0.112
Urea Nitrogen (mmol/L)	15.35 (10.00 24.28) (343)*	8.93 (6.07 13.92) (2096)	<0.001	8.65 (6.18 13.65) (73)	7.73 (5.73 11.64) (564)	0.096
Glucose (mmol/L)	7.38 (5.83 9.16) (341)	6.44 (5.49 7.83) (2069)	<0.001	6.93 (5.28 10.02) (73)	6.20 (5.06 8.40) (561)	0.070
pH	7.37 (7.27 7.43) (301)	7.41 (7.37 7.45) (1514)	<0.001	7.39 (7.34 7.44) (37)	7.39 (7.37 7.43) (213)	0.949
CTroponinT (ng/ml)	1.30 (0.30 5.25) (169)*	0.70 (0.10 4.40) (875)	0.019	0.150 (0.030 0.825) (58)	0.042 (0.016 0.205) (457)	0.001
RBC ($\times 10^{12}$/L)	3.37 (3.02 3.73) (341)*	3.45 (3.16 3.83) (2079)	0.001	3.94 (3.19 4.45) (72)	4.06 (3.45 4.59) (557)	0.101
Uric Acid (μmol/L)	368.8 (194.8 588.8) (26)	345.0 (232.0 511.5) (119)	0.690	394.7 (273.8 536.4) (71)	379.1 (290.1 477.1) (557)	0.366
Chloride (mmol/L)	104.0 (99.0 109.2) (342)	104.0 (100.0 107.0) (2083)	0.343	103.7 (99.9 107.7) (73)	103.4 (100.0 106.3) (561)	0.546
Calcium (mmol/L)	2.05 (1.93 2.19) (332)*	2.12 (2.02 2.19) (1896)	<0.001	2.16 (2.04 2.25) (72)	2.17 (2.07 2.28) (556)	0.194
Potassium (mmol/L)	4.20 (3.85 4.60) (341)	4.00 (3.80 4.40) (2082)	<0.001	4.09 (3.77 4.60) (73)	4.00 (3.64 4.36) (563)	0.160
Sodium (mmol/L)	140.0 (136.0 144.0) (340)	139.0 (136.0 142.0) (2083)	0.026	139.4 (135.9 141.6) (73)	139.7 (136.8 142.0) (562)	0.332
Total Protein (g/L)	53.0 (42.7 58.2) (30)*	56.0 (49.0 62.0) (87)	0.076	62.8 (55.3 69.5) (71)	65.6 (60.0 70.9) (556)	0.030
Albumin (g/L)	27.0 (22.0 31.0) (225)*	29.0 (25.0 34.0) (900)	<0.001	32.4 (29.5 37.4) (65)	36.0 (32.2 40.0) (516)	<0.001
PO_2 (mm Hg)	95.0 (70.7 135.2) (298)#	94.0 (77.0 123.0) (1482)	0.896	83.2 (64.4 102.7) (37)	77.7 (67.3 96.9) (213)	0.837
PCO_2 (mm Hg)	39.5 (33.0 48.0) (298)*	41.0 (36.0 46.0) (1482)	0.041	33.4 (29.8 41.9) (37)	36.6 (32.4 42.4) (213)	0.054
Cholesterol (mmol/L)	3.26 (2.72 4.03) (35)#	3.85 (3.01 4.72) (265)	0.029	4.00 (3.13 5.15) (58)	3.98 (3.29 4.79) (462)	0.838
Triglyceride (mmol/L)	1.25 (0.86 1.98) (59)	1.26 (0.87 1.76) (318)	0.874	1.16 (0.79 1.62) (58)	1.19 (0.84 1.79) (461)	0.493
NT-proBNP (pg/ml)	9723 (6199 23722) (13)	6479 (2468 13274) (64)	0.062	7827 (2421 20980) (52)	4052 (1382 10281) (431)	0.011

*P<0.01 compare to patients that died in PLAGH; #P<0.05 compare to patients that died in PLAGH. Abbreviations: BIDMC, Beth Israel Deaconess Medical Center; PLAGH, People's Liberation Army General Hospital; ICU, Intensive Care Unit; RBC, red blood cell; NT-proBNP, amino terminal B-type natriuretic peptide.

Table 4. Multivariate logistic analysis of the association of age and eight serum parameters with in-hospital mortality from BIDMC and PLAGH

		B	SE	Wald	*P*	OR	95% CI for OR	
							Lower	Upper
BIDMC	Age	0.037	0.007	28.300	0.000	1.038	1.024	1.052
	Glucose	0.102	0.030	11.257	0.001	1.107	1.043	1.175
	Urea Nitrogen	0.062	0.009	47.702	0.000	1.064	1.046	1.083
	PH	-0.917	0.124	54.492	0.000	0.400	0.313	0.510
	Potassium	0.704	0.144	23.887	0.000	2.022	1.525	2.681
	Albumin	-0.065	0.016	17.191	0.000	0.937	0.909	0.966
PLAGH	Age	0.027	0.011	6.129	0.013	1.027	1.006	1.049
	cTroponinT	0.109	0.045	5.899	0.015	1.115	1.021	1.217
	Albumin	-0.078	0.025	9.935	0.002	0.925	0.881	0.971

Abbreviations: BIDMC, Beth Israel Deaconess Medical Center; PLAGH, People's Liberation Army General Hospital; CI, Confidence interval; OR, Odds ratio; SE, Standard error.

NT-proBNP levels of patients were higher while RBC, uric acid, calcium, total protein, albumin and cholesterol levels of patients were lower in BIDMC than PLAGH.

Baseline demographics and 18 serum parameters were evaluated in the two hospitals (**Table 3**). Mann Whitney U tests comparing patients that died in hospital and those discharged revealed significant differences in admission age and 12 serum indicators in BIDMC ($P<0.05$) (**Table 3**). Among the indexes examined, age and serum concentrations of creatinine, urea nitrogen, glucose, cTroponinT, potassium, sodium, cholesterol and NT-proBNP were significantly higher, while pH, RBC, calcium, albumin and PCO_2 were markedly decreased in patients that died in hospital, compared to dischargers. Correspondingly, admission age and four serum indicators were significantly different between patients that died in hospital and dischargers in PLAGH ($P<0.05$) (**Table 3**). Among the indexes examined, age and serum cTroponinT and NT-proBNP of patients that died were markedly increased while serum total protein and albumin contents were significantly decreased compared to those of discharged patients.

Baseline indicators of patients with HF that died in the two hospitals were additionally compared (**Table 3**). Patients that died in BIDMC were significantly higher in age and contained elevated serum concentrations of creatinine, UN, cTroponinT, PO_2 and PCO_2, but lower RBC, calcium, total protein, albumin, and cholesterol than those in PLAGH (**Table 3**).

To further explore the influence of all the serum parameters in BIDMC that showed significance in univariate analysis between dead and discharged ICU patients, we selected 12 significant indexes (age, creatinine, UN, glucose, pH, cTroponinT, RBC, calcium, potassium, sodium, albumin, PCO_2) to perform multivariate binary logistic analysis under forward conditions, and predicted probability was saved as a new variable. In total, only 103 records of patients that died in hospital and 368 dischargers were analyzed. Age and serum UN, glucose, pH, potassium, albumin were entered into the description function. To increase the records entered, we censored some variables and ultimately selected eight significant indexes (age, creatinine, UN, glucose, pH, potassium, albumin, PCO_2) for analysis. The same indexes, including age and serum UN, glucose, pH, potassium, albumin were entered into the description function (**Table 4**). Overall, 208 records of patients that died in hospital and 708 records of dischargers were entered into the function this time. For PLAGH patients, five significant indexes (age, cTroponinT, total protein, albumin and NT-proBNP) were selected to perform multivariate binary logistic analysis, and 51 patients that died in hospital and 401 dischargers analyzed. Age, serum cTroponinT and albumin were finally entered into the description function (**Table 4**).

Discussions

To our knowledge, this is the first documented comparison of laboratory tests and hospital

mortality rates in ICU patients with HF between large teaching hospitals in the USA and China. The results may aid in elucidating the risk factors underlying HF in ICU patients in the two countries. The differences in the laboratory test prescription rates between the two hospital services indicate that health practitioners in PLAGH take a more aggressive approach in examining ICU patients.

While the mortality rates in both hospitals were not significantly different, the rate in BIDMC was higher than that in PLAGH. This tendency may have no association with medical treatment, and can be explained by a number of reasons. Firstly, baseline investigations of ICU patients with HF were different between the two hospitals indicative of more serious conditions of patients in BIDMC than PLAGH, which may be related to the increased mortality in the US hospital. Secondly, patients in the two hospitals were racially different. Thirdly, in China people traditionally prefer to enjoy their advanced years at home, and patients would generally choose to die in their own homes rather than hospitals. Consequently, many patients are discharged from hospital during the later stages of death, possibly contributing to the decreased hospital mortality rate in PLAGH. In this study, we did not collect follow-up data from discharged patients.

Renal insufficiency in admitted patients with HF was correlated with increased risk of morbidity and mortality [9] and poorer renal function with HF [10]. Sztrymf and colleagues found that the creatinine level at admission was associated with hospital mortality in ICU patients with Acute Heart Failure (AHF) and pulmonary arterial hypertension [11]. Higher baseline estimated glomerular filtration rate (eGFR) is an important determinant of kidney function recovery for patients who previously initiate hemodialysis, but patients with heart failure are less likely to recover even with higher baseline eGFR [12]. Our previous findings support this conclusion (the corresponding manuscript has been submitted for publication). Accordingly, we aimed to explore the association of renal function with hospital mortality in ICU patients with HF. To achieve this, we selected all ICU patients with HF who underwent serum creatinine and urea nitrogen examination in both hospitals for comparative analysis. Similarly, these two indexes in patients that died in hospital were significantly higher than those discharged in BIDMC, and tended to increase, although not to a significant extent, in PLAGH, possibly due to the limited sample number.

In both hospitals, age was higher and serum albumin levels lower in patients that died in hospital than those discharged. An observational study by Jinwoo *et al.* [13] showed that older-age of patients admitted to medical intensive care unit, and to a lower extent, heart and respiratory failure are the common risk factors for venous thromboembolism. Shirakabe *et al*. [14] found that lower serum albumin is associated with alkalosis in AHF, which is linked to higher hospital mortality, compared to acid-base balance in AHF. Poor serum albumin levels indicated malnutrition and those patients had experienced HF for a period of time. Serum albumin could be used for prognosis of hospital mortality to a certain extent. Metabolic alkalosis is a common complication of diuretic therapy in patients with HF. Severe metabolic alkalosis has been associated with adverse effects, and shown to contribute to increased mortality [15]. However, lower normal pH was statistically associated with hospital mortality in BIDMC in this study.

Individuals with diabetes mellitus are at very high risk of incident cardiovascular disease. A retrospective cohort study of 4419 subjects with no prevalent cardiovascular disease or HF by Hicham *et al*. [16] showed that dysglycemia is associated with minor alterations in cardiac structure, as well as left ventricular diastolic and systolic function. Another study by Folsom *et al*. [17] revealed that normal blood glucose and greater achievement of Life's Simple 7 recommended by American Heart Association in middle age are associated with reduced lifetime incidence of HF, with better preservation of cardiac structure and function in later life. In the current investigation, ICU patients with HF that died in hospital contained significantly greater serum glucose levels than dischargers in BIDMC and showed an increasing tendency of serum glucose in PLAGH.

Recently, a controversial negative result from the EVEREST Trial by Khan and co-workers showed that in-hospital potassium change is not associated with either in-hospital or post-

discharger mortality over a median follow-up of 9.9 months [18-20]. A meta-analysis by Salah *et al*. [21] revealed that a percentage decline of >15% in serum baseline potassium in patients hospitalized for ADHF is an independent predictor of 6-month any-cause mortality. Our data showed that baseline serum potassium is markedly higher in patients that died from any cause in hospital than dischargers in BIDMC and associated with hospital mortality.

Natriuretic peptides (NP) have solid indications for diagnosis of ADHF and prognosis of HF [22-24]. Treatment of HF guided by NP has been shown to reduce any-cause mortality and hospitalization in patients aged <75 years [25]. NT-proBNP has plays an equivalent role to that of NP. Compared with standard care, a NT-proBNP guided strategy aimed at decreasing NP levels improved outcomes (morbidity and first hospitalization for HF) among patients with chronic systolic HF [26]. Although NT-proBNP has relatively modest accuracy for diagnosis of HF, the parameter has served as a valuable prognostic marker in patients with coronary disease or left ventricular hypertrophy [27-29]. In the current study, although NT-proBNP did not effectively distinguish the patients that died in hospital from dischargers, a statistically significant increase was observed in hospital deaths in PLAGH. Since data for BIDMC were measured seven years earlier and the examination rate of NT-proBNP was low (only 3.1%), we did not observe a significant difference between the two groups of patients in this hospital. However, NT-proBNP showed an increasing trend in patients that died in hospital compared with dischargers.

The present study has several limitations. Firstly, as this was a retrospective study, only admission data and mortality rates in hospital were included. We did not collect follow-up data on discharged patients owing to a number of difficulties. Secondly, the case numbers of PLAGH were smaller than those of BIDMC, which did not make the comparison equivalent. Thirdly, the study did not include the newest data from ICU patients with HF from BIDMC. Fourthly, treatments between the two hospitals could not be compared, and further comparative research between ICU patients from different countries is essential for optimization of treatment.

Studies comparing ICU patients in teaching hospitals between the USA and China may provide insights that facilitate effective HF prognosis and identification of risk factors for mortality. The mortality rate of ICU patients with HF from BIDMC was increased relative to that of patients from PLAGH, although this difference between the two hospitals was not significant. Comparison of hospital mortality rates and baseline investigations between the USA and China disclosed that age and albumin in both hospitals, in addition to serum urea nitrogen, glucose, pH, potassium in BIDMC and serum cTroponinT in PLAGH are associated with in-hospital mortality. Our findings may contribute to the evaluation and establishment of effective prognostic and risk factors for hospital mortality in ICU patients with HF.

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Disclosure of conflict of interest

None.

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