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ORIGINAL ARTICLE

Clinical performance and quality measures for heart failure management in China: the China-Heart Failure registry study

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Abstract

Aims Heart failure (HF) remains a major public health problem with increasing prevalence in China. This study evaluated the clinical performance and quality measures for HF management to identify gaps in the standardization of care for patients hospitalized for HF in China.

Methods and results Following the results of China-HF stage I (2012–2015), the second stage of the China-HF was launched in 2017. Among 113 hospitals with ≥100 cases, the China-HF Stage II assessed the quality of care measures for HF and compared results with previous data in China and the US-based Get with The Guidelines-Heart Failure (GWTG-HF) registries. In total, 34 938 patients hospitalized with HF were enrolled from January 2017 to October 2020. Echocardiographic left ventricular function and natriuretic peptide test were performed in 93.7% and 93.0% of the cases, respectively. Adherence to standardized guidelines in China-HF stage II was higher than that in the China-HF stage I, but generally lower than GWTG-HF registry with 78.2% of eligible patients was prescribed oral diuretics, 78.7% renin-angiotensin-system inhibitors, and 82.2% beta-blockers. Implantable cardioverter-defibrillators and cardiac resynchronization devices were implanted in 3.9% and 14.6%, respectively. In contrast, the proportion of eligible patients discharged with spironolactone (87.8%) was higher than GWTG-HF. The median length of hospitalization was 9 (6, 12) days, and 938 (2.8%) patients died or withdrew from treatment during hospitalization.

Conclusions Despite significant improvements in the use of guideline-recommended testing and therapy, there remain major gaps in quality of care for patients hospitalized for HF in China that are generally larger than gaps observed in the United States.

Keywords Heart failure; Medical union; Clinical performance; Quality measures; Quality improvement

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Introduction

Heart failure (HF) is a major health issue that affects millions of patients and causes enormous economic burdens on countries throughout the world. The prevalence of HF has been approximately 1%–2% among adults in developed countries.[1] Recent evidence from the China Hypertension Survey (CHS), 2012–2015, showing that 1.3% of the Chinese adult population aged ≥35 years had HF, leads to an estimated 8.9 million patients with HF in the country.[2,3]

Although recent years have seen advancements in diagnosis and treatment of HF, gaps in the standardization of HF management in China persist. On the one hand, there is disparity in the understanding of standardized diagnosis and treatment of HF among hospitals in different regions of China, as well as the impact of varying levels of equipment and medical personnel on potential under-diagnosis and variable treatment. On the other hand, many patients with HF fail to receive effective management and education after discharge, increasing the risk of rehospitalization for worsening HF or death. These problems emphasize a pressing need to perform a nation-wide evaluation of quality of HF care in order to improve the management of HF in China as a whole. In response to this need, the China-HF registry was designed to assess clinical characteristics, management, and outcomes of HF in a large cohort of patients in China, and the results from the first stage (2012–2015) were published in 2017.[4] In response to deficiencies like under-standardized of HF management that reflected by this report, we have established the Heart Failure Medical Union of the National Center for Cardiovascular Diseases (HFMU-NCCD) and carried out continuous quality promotion projects. Meanwhile, the China-HF stage II (2017–2020) study was launched to evaluate the current status of HF management in China and the result of quality promotion.

The aim of this programme was to inform development of future quality improvement initiatives designed to improve the quality of HF care in China. In the current manuscript, we present the primary results for the China-HF stage II registry to characterize quality of care for patients hospitalized for HF in contemporary Chinese clinical practice and to place the quality of care in the context of prior results from China as well as the care provided in the United States.

Methods

Study design and participants

The China-HF registry, as previously described,[4] is a prospective, multi-centre study that recruited individual hospitalized patients aged 18 years or older, with a primary diagnosis of HF at discharge according to the Chinese HF guidelines.[5,6] According to the 2021 European Society of Cardiology (ESC) guidelines for heart failure, HF with reduced, mildly-reduced and preserved ejection fraction (HFrEF, HFmrEF, and HFpEF) was defined as left ventricular ejection fraction (LVEF) ≤ 40%, 41%–49%, and ≥50%, respectively.[7] In China-HF stage II, we included patients fulfilling the eligibility above and admitting from January 2017 to October 2020, no exclusion criteria were defined. We pre-specified to limit analysis to data from centres with 100 or more cases. The investigation conforms with the principles outlined in the "Declaration of Helsinki" (*Br Med J* 1964; ii: 177). This study was approved by the ethics committee of Fuwai Hospital (Beijing, China). A waiver of patient informed consent was granted because data were used for quality improvement.

Data collection and variables

Based on relevant guidelines and documents for HF treatment in China, United States, and Europe,[1,5,6,8,9] and the quality indicators presented by the ESC,[10] while taking into account the national conditions of China, the China-HF and HFMU-NCCD investigators established the Medical Quality Evaluation Index System for HF treatment in China, including a process index and outcome index (*Table* S1). The former included the diagnosis and evaluation, guideline-directed medical therapy (GDMT) and device therapy of HF, whereas the latter included length of stay (LOS) during hospitalization and in-hospital mortality (included death during hospitalization and treatment withdrawal in end-stage patients because many Chinese patients prefer not to die in the hospital). The index for the GDMT of HF included the use of oral diuretics, renin-angiotensin system inhibitors (ACEI, ARB, or ARNI), oral beta-blockers, and mineralocorticoid receptor antagonists (only spironolactone is available in China) for appropriate patients at discharge. Device therapy of HF included the application of implantable cardioverter-defibrillator (ICD) or cardiac resynchronization therapy (CRT) for appropriate patients during the index hospitalization. Appropriate patients were defined by the class I recommendations in the guidelines and excluded patients in whom such therapy was contraindicated or used with caution for treatment (*Table* S2).

Quality measures in the two stages of China-HF were further compared with Get with The Guidelines-Heart Failure (GWTG-HF) registries in this study. The GWTG-HF registry is a programme overseen by the American Heart Association (AHA) for quality improvement, which enrols HF patients admitted to participating hospitals in the United States. A recent GWTG-HF publication included 423 333 HF patients aged ≥18 years in 488 hospitals from 1 January 2010 through 31 December 2016, excluded patients who had no defined discharge status, were discharged to hospice, left against

medical advice, or if race or left ventricular ejection fraction (LVEF) were missing.[11]

Statistical analysis

Continuous variables were expressed as the mean ± standard deviation (SD) or median [inter-quartile range (IQR)], and categorical variables as numbers (*n*) and percentages (%). The statistical significance of differences was assessed using Student's *t*-test or Mann–Whitney *U* test for continuous variables, and the χ^2 test for categorical variables. All tests were two-tailed, with statistical significance set at $P < 0.05$. Statistical analysis was performed in the SPSS 19.0 statistical software package (IBM Corp., USA).

Results

As of 30 October 2020, 418 hospitals across China participated in HFMU-NCCD and initiated data entry. Of these, 113 had recorded at least 100 cases. Altogether, 34 938 patients admitted between January 2017 and October 2020 were included for analysis of China-HF stage II (*Figure 1*). The number of patients enrolled by provinces was shown in *Figure S1*.

Baseline characteristics

In China-HF stage II registry, the mean age of patients was 67 years, 60.8% were male, the mean body mass index (BMI) was 24.0 kg/m^2, and the mean systolic blood pressure (SBP) was 130 mmHg. Common aetiologies included coronary artery disease (48.3%), valvular heart disease (18.7%), and dilated cardiomyopathy (16.3%). Common co-morbidities included hypertension (56.3%), diabetes mellitus (31.5%), and atrial fibrillation or flutter (17.6%). Comparison of aetiologies and co-morbidities of HF in patients with HFrEF, HFmrEF, and HFpEF was shown in *Figure* S2. Compared with GWTG-HF, patients in China were younger, had lower SBP on admission, and a significantly lower proportion of women. Patients in China-HF stage II had higher rates of HFmrEF and lower rates of HFpEF compared with the GWTG-HF. Moreover, the prevalence of hypertension, diabetes, and atrial fibrillation/flutter were significantly lower in China when compared with that in the United States (*Table 1*). The median B type natriuretic peptide (BNP) was 606 (187, 1600) pg/mL and the median N-terminal pro-B type natriuretic peptide (NT-pro BNP) was 2698 (945, 6626) pg/mL at admission in patients enrolled in China-HF stage II. The proportion of patients with abnormal laboratory tests in China-HF stage II was shown in *Table* S3.

Figure 1 Flowchart of the data collection protocol. HFMU-NCCD, the Heart Failure Medical Union of the National Center for Cardiovascular Diseases.

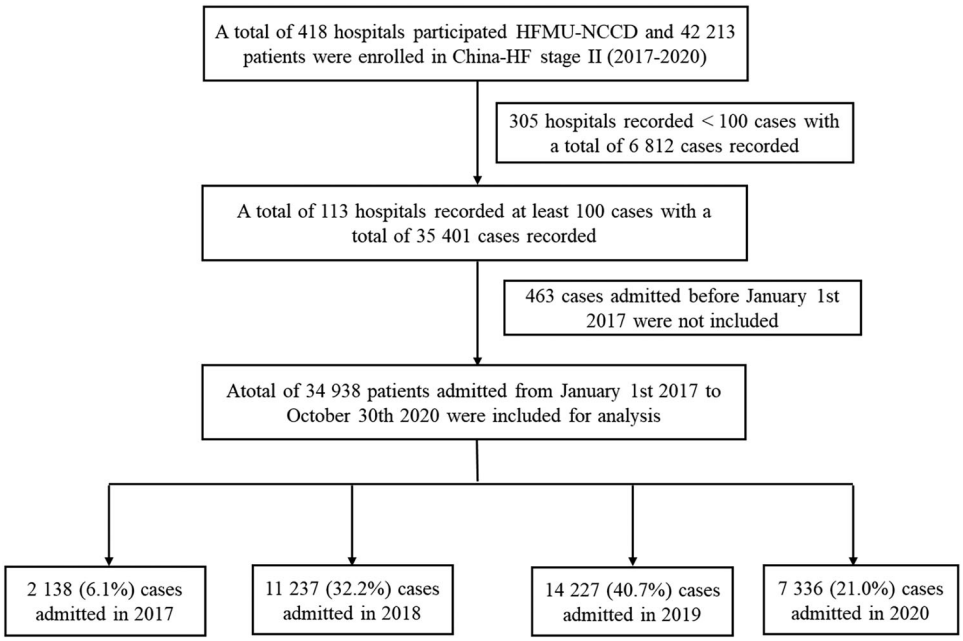


Table 1 Baseline characteristics of patients enrolled in China-HF stage I, stage II, and GWTG-HF in the United States

Patient characteristics	China-HF stage II (n = 34 938) Jan 2017 to Oct 2020	China-HF stage I (n = 13 687) Jan 2012 to Oct 2015	GWTG-HF in the United States (n = 423 333) Jan 2010 to Dec 2016
Age (years)	67 ± 14	65 ± 15	72 ± 15
Male	21 241 (60.8)	8093 (59.1)	219 286 (51.8)
Body mass index (kg/m^2)	24.0 ± 4.0	23.7 ± 4.3	29.2 ± 6.2
SBP (mmHg)	130 ± 24	128 ± 26	142 ± 30.0
DBP (mmHg)	79 ± 16	76 ± 18	78 ± 19
Heart rate (b.p.m.)	85 ± 21	82 ± 25	86 ± 20
LVEF (%)			
Valid cases	32 714 (93.6)	11 289 (82.5)	423 333 (100)
Mean	43 (33, 56)	48 (35, 60)	
HFrEF	13 144 (40.2)	4126 (36.5)	183 727 (43.4)
HFmrEF	7152 (21.8)	1874 (16.6)	57 573 (13.6)
HFpEF	12 448 (38.0)	5289 (46.9)	182 033 (43.0)
NYHA function class (%)			
Valid cases	32 808(93.9)	12 756 (93.2)	
II	6087(18.6)	2756 (21.6)	
III	15 817(48.2)	5775 (45.3)	
IV	10 904(33.2)	3980 (31.2)	
Aetiology			
Coronary artery disease	16 885 (48.3)	6785 (49.6)	209 973 (49.6)
Valvular heart disease	6517 (18.7)	2126 (15.5)	
Dilated cardiomyopathy	5687 (16.3)	2186 (16.0)	
Co-morbidities			
Hypertension	19 659 (56.3)	6968 (50.9)	343 323 (81.1)
Diabetes mellitus	11 018 (31.5)	2877 (21.0)	190 500 (45.0)
Atrial fibrillation/flutter	6143 (17.6)	2932 (24.4)	165 947 (39.2)
Obesity	3269 (15.0)	1449 (13.5)	

Abbreviations: GWTG-HF, Get With The Guidelines–Heart Failure Registry; SBP, systolic blood pressure; DBP, diastolic blood pressure; LVEF, left ventricular ejection fraction; HFrEF, heart failure with reduced ejection fraction; HFmrEF, heart failure with midly-reduced ejection fraction; HFpEF, heart failure with preserved ejection fraction.
Note: Data are shown as n (%) or mean (standard deviation). Obesity was defined as BMI ≥ 28.

Diagnosis and assessment of heart failure

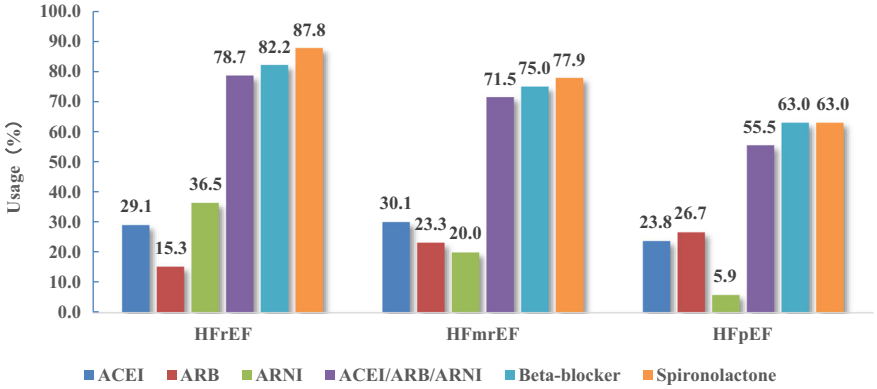
LVEF was measured in 32 714 (93.7%) patients of China-HF stage II, including 13 144 (40.2%) of HFrEF, 7152 (21.8%) of HFmrEF, and 12 338 (38.0%) of HFpEF (*Table 1*). Furthermore, among the 30 379 patients with documented dates of echocardiography, LV function was measured within 3 days of admission in 24 101 patients (79.3%). The results of the natriuretic peptide (NP) test were recorded for 32 504 patients (93.0%), including BNP and/or NT-pro BNP. Furthermore, among 29 795 patients with documented NP test time, 24 996 (83.9%) performed NT test within 24 h of admission (*Figure* S3A,B).

Guideline-directed medical therapy (GDMT) for heart failure

Among 29 168 patients discharged alive, 22 807 (78.2%) were prescribed oral diuretics, the majority of which were loop diuretics (91.8%). Among patients prescribed loop diuretics, 83.2% received furosemide, 15.4% received torasemide, and 1.4% received bumetanide. Overall, 936 patients (3.2%) received tolvaptan at discharge, which was combined with other oral diuretics in 79.5% of patients.

Of 10 057 patients with HFrEF and eligible for RAS inhibitors, 7192 (78.7%) were prescribed RAS inhibitors (including ACEI, ARB, or ARNI) at discharge. Specifically, the administration rates of ACEI, ARB, and ARNI were 28.8%, 15.2%, and 36.5%, respectively. In HFmrEF and HFpEF patients without contraindication, RAS inhibitors were prescribed for 71.5% and 55.5%, respectively (*Figure 2*). The usage of RAS inhibitors in patients with hypotension or severe renal dysfunction is shown in *Figure* S4. Specifically, among 411 patients with documented SBP < 90 mmHg, utilization rates of ACEI, ARB and ARNI were 17.5%, 5.4%, and 40.4%, respectively. Besides, 44 patients (10.1%) received ACEI, whereas 35 (8.0%) received ARB, and 86 (19.7%) received ARNI of 436 patients with serum creatine >221 μmol/L. Overall, among 819 HFrEF survivors with SBP < 90 mmHg or serum creatine >221 μmol/L, the usage of ACEI, ARB, and ARNI was 13.7%, 6.6%, and 30.0%. The usage rates for ACEI and ARB de-

Figure 2 Usage of Guideline-directed drugs in patients with HFrEF, HFmrEF or HFpEF in China-HF stage II. ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor neprilysin inhibitor; HFrEF, heart failure with reduced ejection fraction; HFmrEF, heart failure with mid-reduced ejection fraction; HFpEF, heart failure with preserved ejection fraction.



creased, but ARNI and the overall RAS inhibitors increased from 2017 to 2020, which were statistically significant (*P* for trend <0.05, *Figure* S5).

A total of 9036 (82.2%) patients received an evidence-based oral beta-blocker among 10 980 indicated patients with HFrEF at discharge. Besides, beta-blockers were prescribed for 75.0% and 63.0% in indicated patients with HFmrEF and HFpEF. In terms of mineralocorticoid receptor antagonists (only spironolactone is available in mainland China), the prescription in eligible HFrEF patients was 87.8% at discharge. Among eligible patients with HFmrEF and HFpEF, 77.9% and 63.0% were prescribed spironolactone. Ivabradine was an inhibitor of the I_f channel in the sinus node, and it was given to 281 (8.3%) at discharge of the 3374 indicated patients; 1721(29.3%) patients were administered digoxin when indicated, including 44.0% (386/877) of patients with atrial fibrillation or flutter and 26.8% (1335/4991) of patients with sinus rhythm. Changes in the usage of these drugs from 2017 to 2020 in China were shown in *Figures* S6 and S7.

In terms of device therapy for heart failure, 3.9% of eligible patients were implanted ICD and 14.6% were implanted CRT. Among the total of 233 patients who were received CRT and assessed for the above-mentioned indications, 47.2% of which were in accordance with class I, 24.0% with IIa, 8.2% with IIb, and 20.6% with class III.

In-hospital outcomes

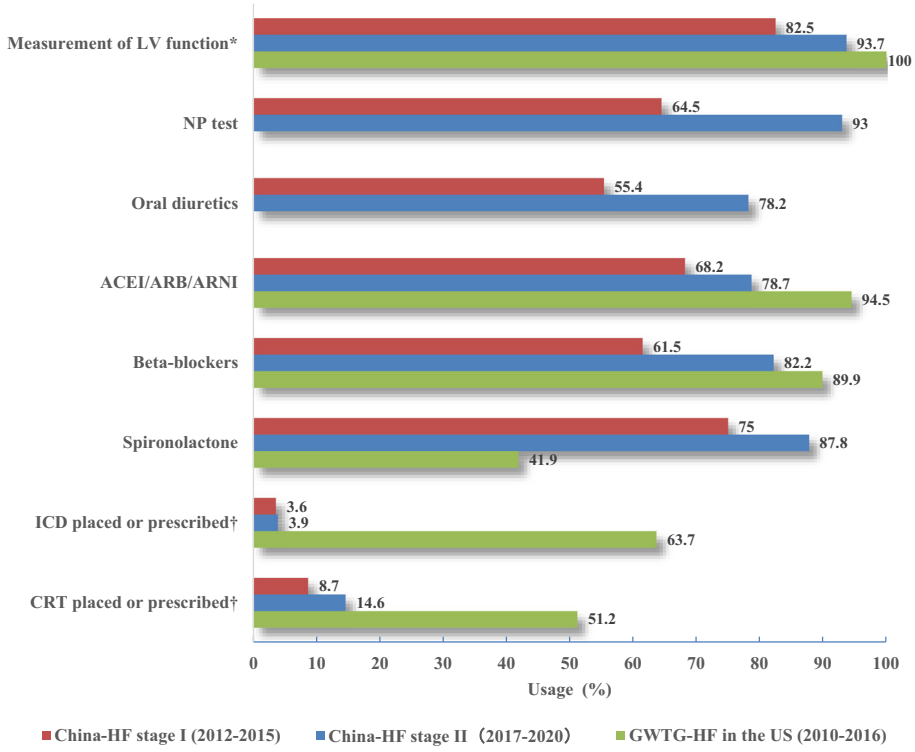
Among 32 677 patients with documented dates of admission and discharge, the median (IQR) of length of stay (LOS) in the hospital was 9 (6–12) days. Among 33 413 patients who had documented outcomes during index hospitalization, 938 patients died or withdrew from treatment. Thus, the in-hospital mortality was 2.8% (3.2% among women and 2.5% among men).

Comparison of quality of care for HF in China and the United States

Compared with the results reported in the China-HF stage I (2012–2015),[4] measurement of LV function, NP test, usage of oral diuretics, overall RAS inhibitors, beta-blockers, or spironolactone for appropriate patients hospitalized with HF was remarkably increased in China-HF stage II ($P < 0.001$). In terms of the type of RAS inhibitor, however, the usage of ACEI or ARB decreased significantly while the usage of ARNI increased dramatically ($P < 0.001$). Although the implantation rate of ICD and CRT in the total population of China HF stage II was significantly higher than in China HF stage I ($P < 0.001$), there was no significant increase of the implantation rate in appropriate population ($P = 0.782$ and $P = 0.114$ for ICD and CRT, *Table* S4). When compared with the GWTG-HF in the United States, notably, the prescription of overall RAS inhibitors, oral beta-blockers, ICD, or CRT in China were lower than those in the United States, whereas spironolactone and ARNI at discharge were higher in China than the United States[11,12] (*Figures 3* and *4*). With regard to in-hospital outcomes, 938 (2.8%) of patients died or withdrew from treatment, which was lower than that of 4.1% in the China-HF stage I,[4] and similar to that of 2.8% in the GWTG-HF registry. However, the median LOS in hospital of 9 days was remarkably longer than that of 4 days in the GWTG-HF Registry[11] (*Table 2*).

China-HF stage II included 29 728 patients (85.1%) from 87 tertiary hospitals and 5210 patients (14.9%) from 26 non-tertiary hospitals. Utilization rates of LV function measurement, NP test, oral beta-blockers, tolvaptan, and ivabradine at discharge for appropriate patients were higher

Figure 3 Comparison between China-HF stage I, China-HF stage II, and the GWTG-HF registry. NP, natriuretic peptide; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor neprilysin inhibitor; ICD, implantable cardioverter defibrillator; CRT, cardiac resynchronization therapy. *Measurement of LV function by echocardiography in this GWTG-HF publication was 100% because patients missing LVEF were excluded. †The value in China-HF refers to patients who have placed ICD/CRT, whereas in GWTG-HF study, it refers to patients who have placed or prescribed ICD/CRT.



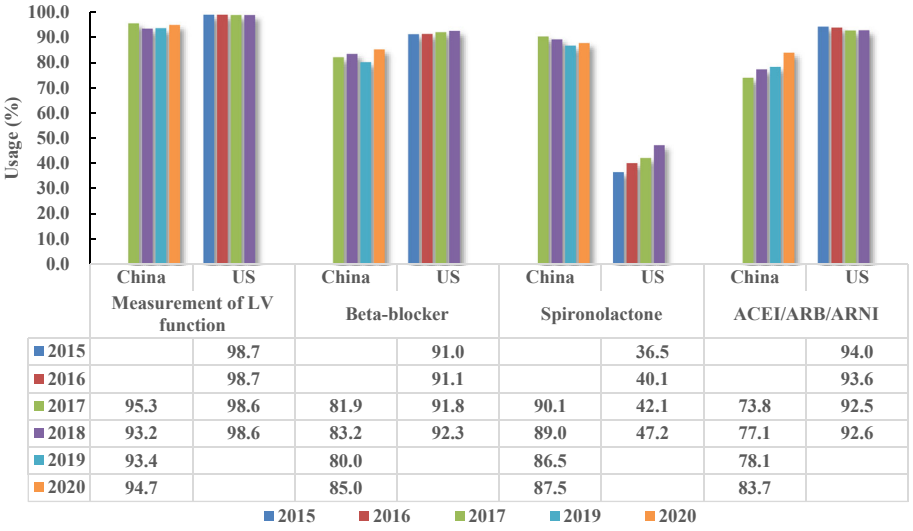
in tertiary hospitals than those in non-tertiary hospitals, whereas oral traditional diuretics, spironolactone, and digoxin were lower in tertiary hospitals ($P < 0.05$). However, there was no significant difference in the overall RAS inhibitors utilization between tertiary and non-tertiary hospitals ($P = 0.081$). Moreover, the prescription of ACEI or ARB was significantly lower while ARNI was significantly higher in tertiary hospitals than those in non-tertiary hospitals ($P < 0.05$, *Figure 5*).

Discussion

In this study, we have described the most recent characteristics and quality measures of patients hospitalized for HF in China. More importantly, we presented the changes in clinical performance and quality measures for HF management from China-HF and compared with the GWTG-HF registry in the United States, in order to identify gaps in the standardization of HF management. Compared with GWTG-HF, patients in China were younger, had lower SBP and BMI on admission, with a lower prevalence of hypertension, diabetes, and AF. In terms of quality of care for HF, patients in China had a lower rate of LV function measurement, overall RAS inhibitors, oral beta-blockers, ICD or CRT but higher spironolactone and ARNI than that in the United States. Despite significant improvements in the use of guideline-recommended testing and therapy, there remain major gaps between tertiary and non-tertiary hospitals in China, as well as between China and the United States.

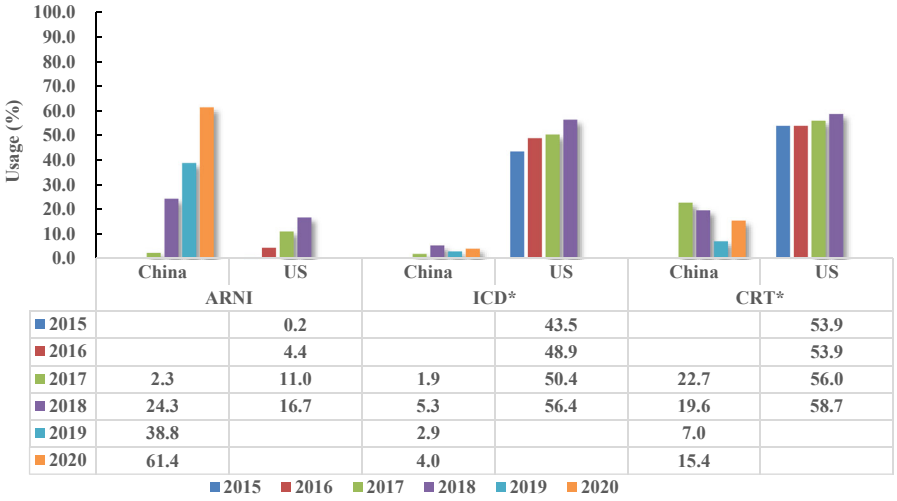
Substantial evidence supports the use of natriuretic peptide and echocardiography in the diagnosis and risk stratification of heart failure.[8] Data in China-HF showed a great improvement in the rate of echocardiographic LV function measurement (82.5% to 93.7%) and NP test (64.5% to 93.0%). The increase in NP test was mostly dramatic, which reflected the improvement of HF diagnosis in China. The persistent nationwide education and training activities for doctors have played an important role in this progress. Gaps in echocardiography tests still existed between different levels of hospitals in China, as well as between China and the United States (98.6% in GWTG-HF in 2018).[12] Therefore, more hospitals in China should be encouraged and assisted to develop the specialty of cardiac ultra-

Figure 4 (A and B) Changes of preferred therapies according to admission date in China-HF stage II (from 2017 to 2020) and GWTG-HF Registry (from 2015 to 2018).[12] NP, natriuretic peptide; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor neprilysin inhibitor; MRA, mineralocorticoid receptor antagonist; ICD, implantable cardioverter defibrillator; CRT, cardiac synchronization therapy. *The value in China-HF refers to patients who have placed ICD/CRT, while in GWTG-HF study it refers to patients who have placed or prescribed ICD/CRT.



	Measurement of LV function		Beta-blocker		Spironolactone		ACEI/ARB/ARNI	
	China	US	China	US	China	US	China	US
2015		98.7		91.0		36.5		94.0
2016		98.7		91.1		40.1		93.6
2017	95.3	98.6	81.9	91.8	90.1	42.1	73.8	92.5
2018	93.2	98.6	83.2	92.3	89.0	47.2	77.1	92.6
2019	93.4		80.0		86.5		78.1	
2020	94.7		85.0		87.5		83.7	

(A)



	ARNI		ICD*		CRT*	
	China	US	China	US	China	US
2015		0.2		43.5		53.9
2016		4.4		48.9		53.9
2017	2.3	11.0	1.9	50.4	22.7	56.0
2018	24.3	16.7	5.3	56.4	19.6	58.7
2019	38.8		2.9		7.0	
2020	61.4		4.0		15.4	

(B)

sound with more experienced echocardiologists, especially in non-tertiary hospitals.

Significant improvements in the use of GDMT in China-HF stage II (2017–2020) compared with China-HF stage I (2012–2015). In China, costs of HF medications have been reduced with the development of medical insurance and most of the drugs have been covered in the medical insurance list including sacubitril/valsartan, which might be part of the reason for the improvements in GDMT. The national-level health promotion programme, such as The National Plan of the Prevention and Control of Chronic Diseases (2012–2015), also prompted the timely conduction of standardized diagnosis and treatment. In addition, the establishment of HFMU-NCCD has improved the understanding of HF for doctors in participating units, and point-to-point assistance and guidance help to improve HF management. From 2017 to 2020 in China-HF stage II, the rates for the total RAS inhibitors and ARNI utilization also showed a trend of steadily

Table 2 Differences in quality measures about HF management and in-hospital outcomes between China-HF stage I, stage II, and GWTG-HF in the United States

	China-HF stage II (n = 34 938) Jan 2017 to Oct 2020	China-HF stage I (n = 13 687) Jan 2012 to Sep 2015	GWTG-HF in the United States (n = 423 333) Jan 2010 to Dec 2016
Diagnosis/evaluation			
Measurement of LV function[a] (%)	93.7	82.5	100
NP test (%)	93.0	64.5	
Medication use			
Oral diuretics (%)	78.2	55.4	
ACEI/ARB/ARNI (%)	78.7	68.2	94.5
Beta-blockers (%)	82.2	61.5	89.9
MRA-spironolactone (%)	87.8	75.0	41.9
Device therapy			
ICD placed/placed or prescribed[b] (%)	3.9	3.6	63.7
CRT placed/placed or prescribed[b] (%)	14.6	8.7	51.2
In-hospital outcomes			
LOS (median [IQR])	9 (6–12)	10 (7–15)	4 (3–6)
In-hospital mortality (%)	2.8	4.1	2.8

Abbreviations: NP, natriuretic peptide; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor neprilysin inhibitor; MRA, mineralocorticoid receptor antagonists; ICD, implantable cardioverter defibrillator; CRT, cardiac resynchronization therapy; LOS, length of hospital stay.
[a]Measurement of LV function by echocardiography in this GWTG-HF publication was 100% because patients missing LVEF were excluded.
[b]The value in China-HF refers to patients who have placed ICD/CRT, whereas in GWTG-HF study, it refers to patients who have placed or prescribed ICD/CRT.

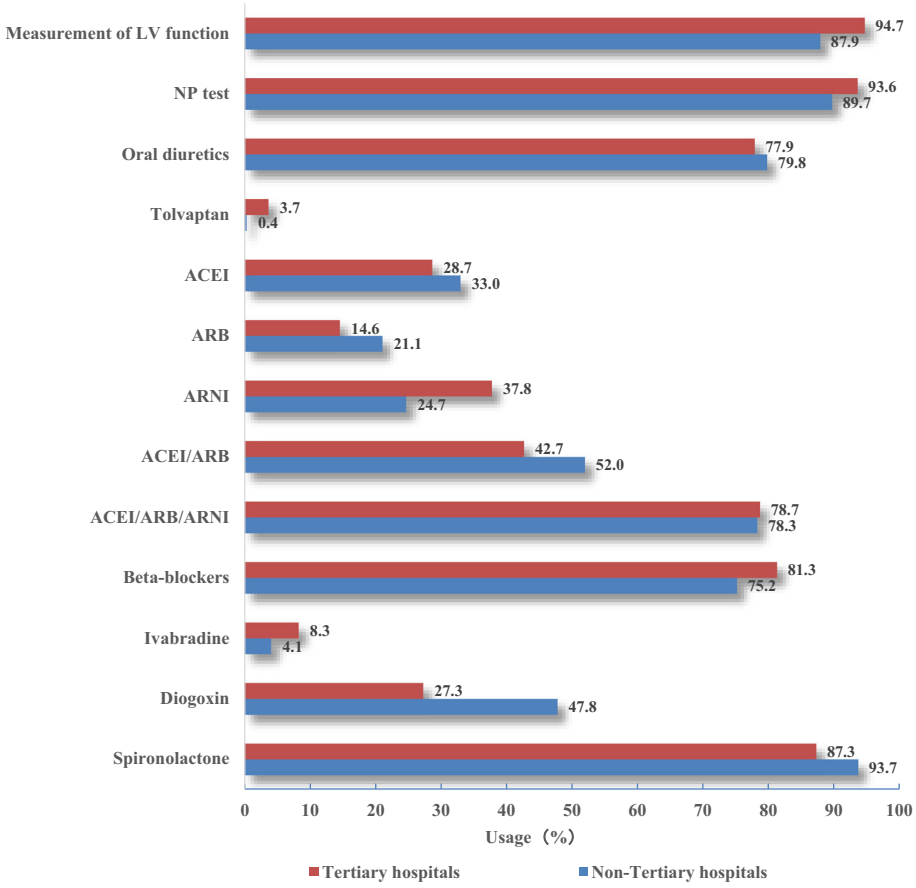
increasing, whereas the trend of change for diuretics, beta-blockers, and spironolactone did not reach a statistical significance. This suggested that the quality promotion work should be continued in the future to further improve the GDMT of HF in China.

The application of RAS inhibitors (ACEI/ARB/ARNI) and beta-blockers was still lower in China-HF than those in the GWTG-HF registry. This was also consistent with the data of Chinese patients in the ASIAN-HF registry (2012–2015) that China had the lowest uptake for ACEI/ARBs (286 [60%]), but the highest uptake for MRAs (372 [78%]), potentially attributed to the low cost of spironolactone.[13] Nevertheless, about 20% of eligible patients did not receive beta-blockers and RAS inhibitors. With regard to RAS inhibitors, one possible explanation is difficulties in determining appropriate populations for benefits due to the considerations of contraindications or intolerance, partly as a result of the relatively high prevalence of CKD and lower systolic blood pressure in Chinese.[14] In this study, nearly 42% of patients have eGFR $<$60 mL/min/1.73 m^2. RAS inhibitors were highly prescribed for patients with hypotension and more severe renal dysfunction in this study.

In terms of types of RAS inhibitors, however, the usage of ACEI or ARB decreased significantly, whereas the usage of ARNI increased dramatically in China-HF stage II (from 2.3% in 2017 to 61.4% in 2020). Notably, the usage of ARNI in China was higher than that in GWTG-HF (24.3% vs. 16.7% in 2018).[12] In 2019, the PIONEER-HF trial had demonstrated that early use of ARNI in hospitalized patients with HF was associated with a greater reduction in NT-pro BNP compared with enalapril, which might boost the use of ARNI in 2019 and 2020 in the United States; however, the current GWTG-HF publication did not have data about the prescription of ARNI in 2019 and 2020.[15] The high usage of ARNI in China suggests that a considerable number of patients switched from ACEI/ARB to ARNI for treatment and the proportion increased over time, partly due to the recommendation update of ARNI in the 2018 Chinese HF guideline.[6] The real-world data from China reflected the good translation of the evidence to practical implementation but variation among hospitals in ARNI use still existed. Further research is needed for the better implementation of evidence from clinical trials into practice.

Underutilization of GDMT in China may partly stem from imbalances of health resources. The current analysis assessed differences in quality measures across 87 tertiary hospitals and 26 non-tertiary hospitals in China. With exception of digoxin and spironolactone therapies, quality measures regarding evaluation and medical therapy were lower in non-tertiary hospitals than tertiary hospitals, among which the difference in the use of ARNI was most significant. These differences are potentially explained by gaps in social-economic development, variation of health insurance coverage, lack of HF specialists and a higher proportion of high-risk patients in China's non-tertiary hospitals. Further efforts are still needed to achieve more accurate identification, timely transportation, and effective monitoring for HF patients in non-tertiary hospitals.

Figure 5 Comparison of China-HF stage II (2017–2020) data between tertiary hospitals and non-tertiary hospitals. NP, natriuretic peptide; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; ARNI, angiotensin receptor neprilysin inhibitor.



It is worth noting that a low proportion of indicated patients received ICD/CRT in China. This is the same as that described in previous studies, such as the ASIAN-HF study, which shows the ICD implantation rate in Asian countries is generally low (12%) with significant regional differences. According to this study, ICD (vs. non-ICD) recipients tended to be older, have tertiary education, and live in high-income regions; besides, the utilization rate tends to increase in areas where the government reimburses for ICD, whereas it tends to decrease in areas with low medical and health care expenditure.[16] The younger age of patients with HF in China and the differences in economy, education, and medical insurance policies among different regions of China might be part of the reasons for the low rate of device treatment. In addition, a certain proportion of patients (20.6%) implanted CRT despite class III recommendation, which reflects that a number of doctors inaccurately understand the indications and do not strictly follow the recommendations of the guidelines. The device implantations increase significantly in the total population but not in the appropriate population in China-HF stage II compared with the China-HF stage I. Therefore, better comprehension of the indications of ICD and CRT may help to improve the referral rate of patients who are eligible for device therapies from non-tertiary hospitals to high-level centres so as to improve the appropriate implantation of ICD/CRT in China.

With regard to in-hospital outcomes, 938 (2.8%) of patients died or withdrew from treatment, which was lower than that of 4.1% in the China-HF registry, and the same as that of 2.8% reported in the GWTG-HF registry.[4,11] However, the median LOS in the hospital of 9 days was remarkably longer than that of 4 days in the GWTG-HF Registry. Relatively improvement of the in-hospital outcome, but a longer LOS in China, suggested potential inefficiency and imbalance of healthcare resources. Pilot projects to introduce Diagnosis-related Groups (DRGs) had been launched in China in 2017. This reform aims to focus on cost control and optimization rather than expanding revenue, promote the efficiency of healthcare resources, and meanwhile ensure quality and safety.[17] Further research is needed to establish appropriate pricing and payment standards based on unified diagnosis and procedures

of HF. Therefore, the practical effects of this reform in HF patients remain to seen in the future.

Limitations

This study has several limitations. First, Among the 418 hospitals participating in HFMU-NCCD, only 113 hospitals (27.0%) enrolled at least 100 cases, of which only 26 were non-tertiary hospitals with 5210 cases (14.9%) included in this report. Moreover, there were some data of imperfect quality, that is, without documented NYHA functional class (3.9%), without test date of echocardiography (7.2%) or NP (8.3%), without electrocardiographic QRS morphology (19.8%) or QRS duration (8.9%), without documented discharge date (4.3%) or in-hospital outcome (4.4%). Third, there was a lack of follow-up in this registry, among the 32 068 survivors with the documented discharge date, only 8814 (27.5%) had recorded at least one follow-up. Therefore, the outcomes after discharge were not analysed in this report. At last, the current analysis used the published data from GWTG-HF as the comparator. However, different study designs and years of enrolment limited comparability between China-HF stage II and GWTG-HF. Measurement of LV function by echocardiography in China could not be compared with that in this GWTG-HF manuscript because patients missing LVEF were excluded.[11]

Conclusion

China-HF stage II was the latest national clinical performance and quality measures in China, reflecting the specific clinical characteristics and great improvement in the standardized diagnosis, guideline-directed medical and device therapies for adult patients hospitalized with HF in China. Nevertheless, there remain significant gaps in the standardization of management of HF compared with the United States. Further efforts are needed to improve the overall quality of care and compliance with guidelines, with a focus on both clinicians and self-management by patients across China. Implementing these changes will be central to improving the prognosis for patients hospitalized for HF.

Conflicts of interest

Dr. Greene has received research support from the Duke University Department of Medicine Chair's Research Award, American Heart Association, Amgen, AstraZeneca, Bristol Myers Squibb, Cytokinetics, Merck, Novartis, and Pfizer; has served on advisory boards for Amgen, AstraZeneca, and Cytokinetics; and serves as a consultant for Amgen, Bayer, Bristol Myers Squibb, Merck, and Vifor. Other authors declare no conflicts of interest.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Number of patients enrolled by provinces.
Figure S2. Comparison of etiologies and comorbidities of HF in patients with HFrEF, HFmrEF and HFpEF.
Figure S3. (A and B) Time distribution of echocardiographic LV function measurement and natriuretic peptide detection.
Figure S4. (A and B) Use of RAS inhibitors in patients with hypotension or severe renal dysfunction.
Figure S5. Changes in the usage of RAS inhibitors according to admission date.
Figure S6. Changes in the usage of oral diuretics, beta-blockers and spironolactone according to admission date.
Figure S7. Changes in the usage of tolvaptan, ivabradine and digoxin according to admission date.
Table S2. Indication of HF medication and device therapy according to Chinese guideline.
Table S3. Differences in laboratory parameters at admission for patients enrolled in China-HF stage I and stage II.
Appendix S1. China-HF Stage II Site Investigators (in order of actual contribution).

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