ORIGINAL RESEARCH

Number of Cardiologists per Cardiovascular Beds and In-Hospital Mortality for Acute Heart Failure: A Nationwide Study in Japan

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***Background*—**Little evidence is available about the number of cardiologists required for appropriate treatment of heart failure (HF). Our objective was to determine the association between the number of cardiologists per cardiology beds for treating patients with acute HF and in-hospital mortality.

***Methods and Results*—**This was a cross-sectional study, and we used the Japanese Registry of All Cardiac and Vascular Diseases Diagnosis Procedure Combination discharge database. The data of patients with HF on emergency admission from April 1, 2012, to March 31, 2014, were extracted. The patients were categorized into 4 groups by the quartiles of the numbers of cardiologists per 50 cardiovascular beds (first group: median, 4.4 [interquartile range, 3.5–5.0]; second group: median, 6.7 [interquartile range, 6.5–7.5]; third group: median, 9.7 [interquartile range, 8.8–10.1]; and fourth group: median, 16.7 [interquartile range, 14.0–23.8]). Using multilevel mixed-effect logistics regression, we determined adjusted odds ratios for in-hospital mortality. We identified 154 290 patients with HF on emergency admissions. There were 29 626, 36 587, 46 451, and 41 626 patients in the first, second, third, and fourth groups, respectively. HF severity, on the basis of New York Heart Association classification, was similar in the 3 groups. Adjusted odds ratios (95% CIs) for in-hospital mortality were 0.92 (0.82–1.04; P=0.20), 0.82 (0.72–0.92; P<0.001), and 0.70 (0.61–0.80; P<0.001) for the second, third, and fourth groups, respectively. The proportion of medication used, including angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, β blockers, and mineralocorticoid receptor antagonists, was positively correlated to the number of cardiologists.

***Conclusions*—**Patients hospitalized for HF in hospitals with larger numbers of cardiologists per cardiovascular beds had lower 30-day mortality. **(*J Am Heart Assoc*. 2019;8:e012282. DOI: 10.1161/JAHA.119.012282.)**

Key Words: cardiologist • database • heart failure • Japanese Registry of All Cardiac and Vascular Diseases • quality assessment

Heart failure (HF) is one of the increasing global problems and leading causes of hospitalization.[1–3] The number of hospitalizations with HF is increasing, largely because of an increase in population size and age.[4] The mortality from HF has slightly improved because of improved care over the past 10 years, which is probably because medical therapy and circulation devices were widely used.[5] However, in-hospital mortality rates from acute HF have remained at the same level in recent years, and the 30-day readmission rate and 5-year mortality of HF are still high.[6–8]

To further improve the quality of treatments for HF, structural and clinical properties of the hospital, including the physician and case volumes, require more attention. Joynt et al showed that patients with HF cared for by high-volume physicians had lower mortality rates, whereas Ross et al showed that patients with HF cared for by high case volume hospitals had lower risk of in-hospital mortality.[9,10] Although high physician volumes led to better outcomes, how to appropriately distribute the physician resources under existing conditions is still incompletely understood. To better understand the relationships between physician resources and HF mortality, we thought that the numbers of

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An accompanying Table S1 is available at https://www.ahajournals.org/doi/suppl/10.1161/JAHA.119.012282

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Received April 2, 2019; accepted July 30, 2019.

Clinical Perspective

What Is New?

- This was the first study that compared the association between the numbers of cardiologists per cardiovascular bed and the clinical outcomes for acute heart failure.
- Patients with heart failure who were admitted to hospitals with larger numbers of cardiologists per cardiovascular bed were associated with lower in-hospital mortality and higher prescription rates for guideline-based treatments of heart failure.

What Are the Clinical Implications?

- Strategy for the appropriate distribution of cardiologists among hospitals or the development of better transportation system to appropriate hospitals may lead to improvements in the in-hospital outcomes and the quality of care for heart failure.

cardiologists per cardiovascular beds would provide more information. However, there has been no study to clarify whether the larger numbers of cardiologists per cardiovascular beds would lead to better outcomes.

The aim of this study was to clarify the relationships between the number of cardiologists per cardiovascular beds and in-hospital HF mortality.

Materials and Methods

Source of Data and Study Patients

The data, analytic methods, and study materials will not be made available to any researchers for purposes of reproducing the results or replicating the procedure.

This was a cross-sectional study, which used the JROAD (Japanese Registry of All Cardiac and Vascular Diseases) database and JROAD–Diagnosis Procedure Combination (DPC) discharge database.

JROAD is the institutional database, conducted by the Japanese Circulation Society. The data were collected from all training hospitals with cardiovascular beds, and the response rate was 100% each year.[11,12] We obtained the following data from the JROAD database: number of hospital beds and cardiologists, presence or absence of cardiac surgery division and coronary care unit, hospital teaching status, and annual number of operations and cardiovascular examinations. The definition of "cardiovascular beds" proposed herein is the total beds of a department of cardiology, not including cardiovascular surgery and pediatrics, on the basis of the JROAD.

JROAD-DPC is the claim database, derived from the Japanese DPC/Per Diem Payment System. JROAD-DPC includes patient data, such as age and sex, main diagnoses and comorbidities, drugs, diagnostic and therapeutic procedures, length of stay, and patient outcomes.[12,13] Of the overall 1620 hospitals included in the JROAD, 808 provided DPC data to the Japanese Circulation Society in 2012 and 2013.

We extracted the patients' data from JROAD and JROAD-DPC database on the basis of the following inclusion criteria: (1) patients hospitalized in cardiovascular departments because of HF from April 1, 2012, to March 31, 2014; and (2) patients hospitalized on emergency admission. The diagnosis of HF was based on the *International Classification of Diseases, Tenth Revision* (*ICD-10*), codes for HF (I50.0, I50.1, and I50.9). Exclusion criteria were as follows: (1) aged <20 years; (2) hospitalized in facilities that treat <10 patients with HF per year; and (3) missing variables.

Statistical Analysis

Data were presented as mean and SD for normally distributed data, median (interquartile range) for nonnormally distributed data, or absolute number (proportion) for categorical data. The patients were categorized into 4 groups by the quartiles of the numbers of cardiologists per 50 cardiovascular beds. The differences among groups were compared using either analysis of variance or Kruskal-Wallis test for continuous variables with Bonferroni correction; or the χ^2 test for noncontinuous and categorical variables. The main outcome was in-hospital mortality. The association between the number of cardiologists per 50 cardiovascular beds and 30-day mortality was analyzed using multilevel mixed-effect logistics regression, with hospital characteristics at the first level and patient characteristics at the second level. The models were adjusted for the following covariates based on previous reports: age, sex, Charlson comorbidity index, Barthel index, New York Heart Association classification, comorbidities (hypertension, dyslipidemia, diabetes mellitus, chronic kidney disease, and atrial fibrillation), presence of cardiac surgery division and coronary care unit, hospital teaching status, and use of ambulance. Barthel index was the assessment tool for activity of daily living. We divided Barthel index on admission into 3 groups: low (0–70), middle (75–95), and high (100), according to a past report.[14]

We then investigated the rates of the following treatments and clinical outcomes according to the number of cardiologists per cardiovascular beds: prescription rates for medications (angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, β blockers, and mineralocorticoid receptor antagonists), rates for cardiac rehabilitation performance and circulation device use, hospitalization costs, and the length of hospital stay. The multilevel logistic models were used to derive adjusted odds ratio of the prescription rates for medications, using the same covariates. In addition, we performed sensitivity analysis for the main outcome, including the patients without emergency hospitalization, because planned patients were taken care of by the same cardiologists and the distribution of patients with planned admission may affect the results.

A 2-sided $P<0.05$ was considered statistically significant. STATA, Version 14 (Stata Corp, College Station, TX) was used for the analysis.

Ethics Statement

This study protocol was approved by the ethical committees in both the Japanese Circulation Society and Nara Medical University (Nara, Japan). The requirement for individual informed consent was waived because no information specifying individuals was included. Data anonymization of the patients' identifiers was performed in the originally provided DPC data.

Results

Patient Selection

From April 2012 through March 2014, we identified a total of 224 594 patients with HF in 808 hospitals. We excluded 27 919 patients hospitalized in other departments and 23 065 patients without emergency hospitalization. We included 173 610 patients with acute HF hospitalized in the cardiovascular departments. We excluded 52 patients aged <20 years, 488 patients hospitalized in facilities treating <10 patients with HF per year, and 18 780 patients with missing variables. Consequently, we analyzed 154 290 patients with acute HF in 770 hospitals (Figure 1).

Hospital Characteristics

The number of cardiologists per 50 cardiovascular beds (median [interquartile range]) was 4.4 (3.5–5.0), 6.7 (6.5–7.5), 9.7 (8.8–10.1), and 16.7 (14.0–23.8) in the first, second, third, and fourth groups, respectively (Table 1). As the number of cardiologists per 50 cardiovascular beds increased, the following variables also increased: number of patients with HF per facility, hospital beds and cardiologists, presence of cardiac surgery division and coronary intensive care unit, and hospital teaching status. The number of patients with HF per cardiologists was lowest in the fourth group. For each condition, larger numbers of cardiologist hospitals were more likely to provide operations such as coronary interventions, coronary artery bypass grafting, catheter ablation, and pacemaker implantation. They were also more likely to offer clinical examinations, such as echocardiography, coronary computed tomography, magnetic resonance imaging, and radioisotope scintigraphy, for all patients hospitalized at each hospital (Table S1).

Patient Characteristics

Approximately 57% of the patients were admitted to the hospitals in the third or fourth groups. By age, they were slightly younger in the larger numbers of cardiologists' groups. There were minimal differences in Charlson comorbidity index, activities of daily living on admission, and New York Heart Association classification. Diabetes mellitus and dyslipidemia were common in the larger numbers of cardiologists' groups, whereas atrial fibrillation and chronic obstructive pulmonary disease were common in the smaller numbers of cardiologists' groups (Table 2).

In-Hospital Mortality

Crude in-hospital mortality rates decreased as the number of cardiologists per 50 cardiovascular beds increased: 12% (N=3344), 10% (N=3620), 9% (N=4058), and 7% (N=2848) for the first, second, third, and fourth groups (Table 3). Unadjusted odds ratios (95% CIs) for in-hospital mortality for HF were 0.86 (0.78–0.94; $P<0.001$), 0.74 (0.67–0.81; $P<0.001$), and 0.58 (0.52–0.63; $P<0.001$) for the second, third, and fourth groups, respectively. The estimate of variance for the mixed model was 0.49, with an SE of 0.02 ($P<0.001$ for the likelihood-ratio test between mixed-effect model and logistic regression model). Adjusted analysis showed that increased number of cardiologists per cardiovascular beds was associated with reduced in-hospital rates of deaths in patients with acute HF. The adjusted odds ratios (95% CIs) for in-hospital mortality were 0.92 (0.81–1.04; $P=0.18$), 0.81 (0.71–0.91; $P<0.001$), and 0.68 (0.59–0.77; $P<0.001$) for the second, third, and fourth groups, respectively (Figure 2). In the sensitivity analysis, we additionally included 3679, 4215, 5581, and 7310 patients with planned admission in the first, second, third, and fourth groups, respectively. The sensitivity analysis showed the robustness of the results (adjusted odds ratios (95% CIs) for in-hospital mortality: 0.92 [0.82–1.04; $P=0.21$], 0.80 [0.71–0.90; $P<0.001$], and 0.68 [0.60–0.78; $P<0.001$] for the second, third, and fourth groups, respectively).

Treatments for HF

The prescription rates of angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, βlockers, and mineralocorticoid receptor antagonists were higher in the larger numbers of cardiologists' groups (Table 3). The adjusted odds ratios for in-hospital medical treatments for patients with HF were as follows. For the second, third, and fourth groups,

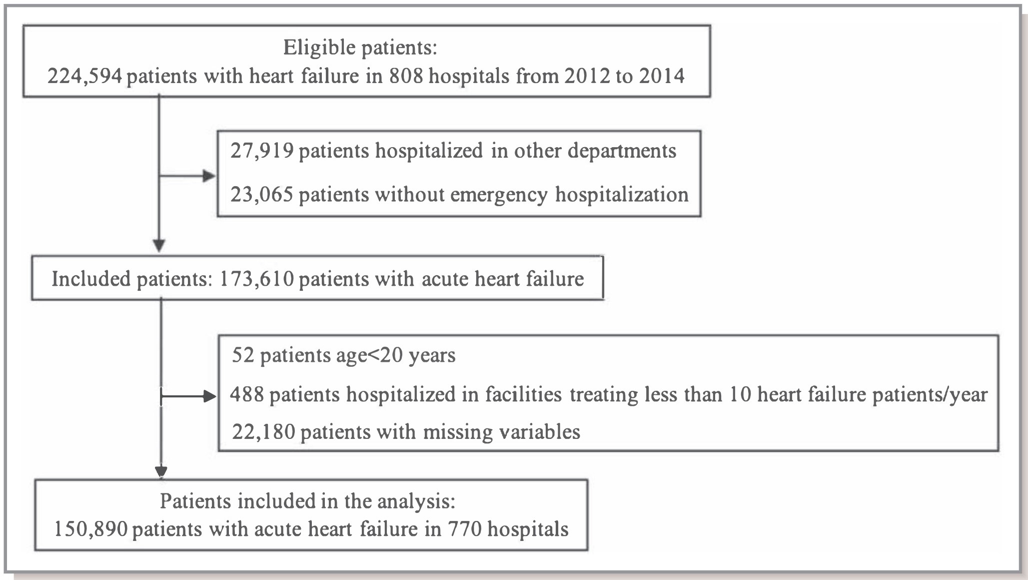

Figure 1. Study flow chart.

adjusted odds ratios (95% CIs) for β-blocker use were 1.09 (0.97–1.22; *P*=0.15), 1.23 (1.09–1.38; *P*<0.001), and 1.59 (1.41–1.81; *P*<0.001), respectively. For angiotensin-converting enzyme inhibitor use, the 3 odds ratios (95% CIs) were 1.04 (0.92–1.17; *P*=0.54), 1.03 (0.91–1.16; *P*=0.62), and 1.38 (1.20–1.58; *P*<0.001), respectively. For mineralocorticoid receptor antagonist use, these odds ratios (95% CIs) were 0.97 (0.87–1.08; *P*=0.59), 1.08 (0.97–1.21; *P*=0.17), and 1.27 (1.13–1.44; *P*<0.001), respectively (Table 4).

A larger number of cardiologists was associated with the higher prescription rate of cardiac rehabilitation, the use of circulation devices (eg, respirators, intra-aortic balloon pump, and percutaneous cardiopulmonary support system), and operations (eg, percutaneous coronary intervention and catheter ablation). These procedures increased as the numbers of cardiologists per 50 cardiovascular beds increased (Table 3).

Hospitalization Costs and the Length of Hospital Stay

In comparison with the smaller number of cardiologists' group, the hospitalization costs in the larger number of cardiologists'

Table 1. Hospital Characteristics by Category of Cardiologist Numbers per Cardiovascular Beds

Characteristics	Total	First Group	Second Group	Third Group	Fourth Group	*P* Value
JCS-certified cardiologists per 50 cardiovascular beds						
Median (IQR)	8.3 (5.7–11.8)	4.4 (3.5–5.0)	6.7 (6.5–7.5)	9.7 (8.8–10.1)	16.7 (14.0–23.8)	
Range	0.63–68.6	0.63–5.7	5.8–8.2	8.3–11.8	11.9–68.6	
No. (%) of hospitals	770	201 (26)	177 (23)	203 (26)	189 (25)	
No. of patients with HF/facilities per y	152 (97–226)	113 (77–170)	150.5 (98–215)	166 (116–242)	186 (118–275)	<0.001
No. of patients with HF/cardiologists per y	43 (28–66)	59 (41–86)	51 (34–73)	40 (28–65)	26 (13–42)	<0.001
Hospital beds	394 (287–547)	300 (210–366)	372 (300–466)	403 (307–539)	590 (413–749)	<0.001
Cardiovascular beds	35 (28–45)	38 (30–48)	35 (30–45)	33 (28–40)	35 (25–45)	0.03
JCS-certified cardiologists	4 (3–6)	3 (2–3)	4 (3–5)	4 (3–6)	7 (5–13)	<0.001
JCS-certified and non–JCS-certified cardiologists	5 (4–8)	3 (2–4)	5 (4–6)	7 (5–8)	11 (8–19)	<0.001
Cardiac surgery facilities, %	59	39	51	64	83	<0.001
Cardiac intensive care units, %	82	68	84	86	90	<0.001
Hospital teaching status, %	82	67	81	88	91	<0.001

Continuous variables were expressed as median (IQR) for skewed distributed data. Kruskal-Wallis test was used to test for mean differences across groups. Categorical variables were presented as frequencies or percentages and were compared using the χ^2 test. HF indicates heart failure; IQR, interquartile range; JCS, Japanese Circulation Society.

Table 2. Patient Characteristics by the Number of Cardiologists per Cardiovascular Beds

Characteristics	Total	First Group	Second Group	Third Group	Fourth Group	*P* Value
JCS-certified cardiologists per 50 cardiovascular beds						
Median (IQR)	8.3 (5.7–11.8)	4.4 (3.5–5.0)	6.7 (6.5–7.5)	9.7 (8.8–10.1)	16.7 (14.0–23.8)	
Range	0.63–68.6	0.63–5.7	5.8–8.2	8.3–11.8	11.9–68.6	
No. (%) of patients	150 890	29 214 (19)	35 911 (24)	45 526 (30)	40 239 (27)	
Age, y	79±12	81±11	79±12	79±12	77±12	<0.001
Male sex, %	52	48	50	52	54	<0.001
Charlson comorbidity index	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)	<0.001
Barthel index, %						
Low (0–70)	65	66	64	65	64	<0.001
Middle (75–95)	9	10	10	10	9	
High (100)	26	24	26	25	27	
NYHA classification, %						
I	7	6	6	7	7	<0.001
II	26	25	26	27	25	
III	34	37	34	32	34	
IV	33	34	34	33	34	
Comorbidities, %						
Hypertension	53	52	53	53	53	<0.001
Diabetes mellitus	34	31	33	34	38	<0.001
Dyslipidemia	37	31	35	37	44	<0.001
Chronic kidney disease	12	12	12	11	12	<0.001
Atrial fibrillation	28	30	28	28	27	<0.001
COPD	12	14	12	11	11	<0.001
Ambulance use, %	40	34	39	42	44	<0.001

Continuous variables were expressed as mean±SD for normally distributed data or median (IQR) for skewed distributed data. Analysis of variance or Kruskal-Wallis test was used to test for mean differences across groups. Categorical variables are presented as frequencies or percentages and were compared using the χ^2 test. COPD indicates chronic obstructive pulmonary disease; IQR, interquartile range; JCS, Japanese Circulation Society; NYHA, New York Heart Association.

group was slightly higher (median hospitalization costs were $6771 [¥744 834], $6890 [¥757 985], $7141 [¥785 572], and $7627 [¥839 057] for the first to fourth groups, respectively). The length of hospital stay was almost the same among groups (Table 3).

Discussion

In this study, we demonstrated that the numbers of cardiologists per 50 cardiovascular beds were associated with lower in-hospital mortality and higher prescription of guideline-based medical therapy for patients with HF. These findings suggest that optimizing the number of cardiologists per cardiovascular beds is needed, and these results provide useful information for optimizing physician resources to reduce the mortality caused by HF.

This was the first study that compared the association between the numbers of cardiologists per cardiovascular bed and the clinical outcomes. Our results are generally consistent with previous studies, which investigated the effect of absolute numbers of physicians on quality of treatment. Although the present study is an observational study and, thus, it is impossible to clarify the cause-effect relationship, there may be some advantages of a larger number of cardiologists per cardiology beds and some disadvantages of a smaller number.

An earlier study[10] showed that the mortality in patients with HF who were admitted to hospitals with higher physician volume per hospital was lower, probably because physicians in high-volume hospitals may be more skilled in decision making about medication use. Other studies showed that patients admitted with acute HF were recommended to be seen for cardiology services; and the larger numbers of

Table 3. Treatments and Outcomes by the Numbers of Cardiologists per Cardiovascular Beds

Variable	Total	First Group	Second Group	Third Group	Fourth Group	*P* Value
JCS-certified cardiologists per 50 cardiovascular beds						
Median (IQR)	8.3 (5.7–11.8)	4.4 (3.5–5.0)	6.7 (6.5–7.5)	9.7 (8.8–10.1)	16.7 (14.0–23.8)	
Range	0.63–68.6	0.63–5.7	5.8–8.2	8.3–11.8	11.9–68.6	
No. (%) of patients	150 890	29 214 (19)	35 911 (24)	45 526 (30)	40 239 (27)	
Medication, %						
ACE inhibitors or ARBs	60	56	60	60	67	<0.001
β Blockers	56	48	53	57	65	<0.001
Mineralocorticoid receptor antagonists	48	46	46	48	53	<0.001
Calcium channel blockers	37	34	35	36	39	<0.001
Statins	29	24	27	29	35	<0.001
Oral hypoglycemic agents	19	17	19	19	21	<0.001
Loop diuretics	88	86	88	87	89	<0.001
Thiazide	11	9	10	11	13	<0.001
Tolvaptan	12	10	12	11	12	<0.001
Cardiac rehabilitation	25	19	20	25	34	<0.001
Device use and operation, %						
Respirator	19	15	18	19	23	<0.001
IABP	0.8	0.3	0.7	1	1.2	<0.001
VA-ECMO	0.1	0.1	0.1	0.1	0.2	<0.001
CRRT	1.5	1.3	1.5	1.4	1.6	<0.001
PCI	4.3	3.5	3.9	4.5	4.9	<0.001
Ablation	0.2	0.1	0.2	0.2	0.3	<0.001
Length of hospital stay, days	18 (11–27)	19 (12–31)	18 (12–29)	17 (11–26)	17 (11–25)	<0.001
Hospitalization cost, $	7133 (4786–11 156)	6771 (4543–10 522)	6890 (4626–10 709)	7141 (4808–11 126)	7627 (5099–12 121)	<0.001
Discharge destination, %						
Home	78	75	78	79	80	<0.001
Other hospitals	9	8	8	9	10	
Nursing homes	4	5	4	3	2	
In-hospital death	10	12	10	9	7	

Continuous variables were expressed as median (IQR) for skewed distributed data. Kruskal-Wallis test was used to test for mean differences across groups. Categorical variables are presented as frequencies or percentages and were compared using the χ^2 test. ACE indicates angiotensin-converting enzyme; ARB, angiotensin II receptor blocker; CRRT, continuous renal replacement therapy; VA-ECMO, venoarterial-extracorporeal membrane oxygenation; IABP, intra-aortic balloon pumping; IQR, interquartile range; JCS, Japanese Circulation Society; PCI, percutaneous coronary intervention. $1=¥110.

cardiologists per hospital beds led to better therapeutic practices in the hospitals with more cardiologists.[15–17] In fact, in our study, patients with HF admitted to larger numbers of cardiologist hospitals more commonly underwent intensive treatments, such as an artificial respirator, intra-aortic balloon pump, and percutaneous coronary intervention. These treatments might be related to better short-term outcomes in patients with HF. In addition, given that contemporary patients with HF are elderly people with multiple comorbidities, multidisciplinary medical treatment and care should be provided by the heart team, consisting of healthcare professionals from varied fields. Generally, in Japan, the heart team medical service is being developed in large hospitals, which usually comprise many cardiologists.

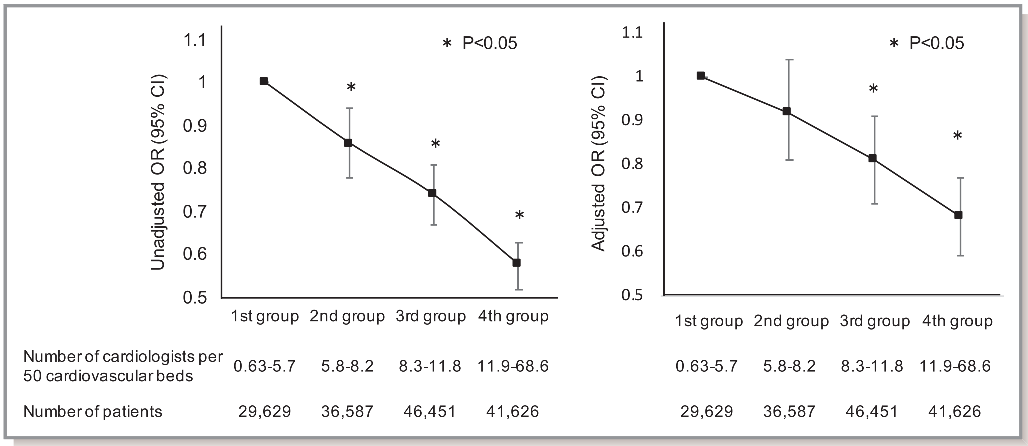

Figure 2. The number of cardiologists and in-hospital mortality for acute heart failure. Model includes age (per 10 years), sex, Charlson comorbidity index, New York Heart Association classification, hypertension, dyslipidemia, diabetes mellitus, chronic kidney disease, atrial fibrillation, cardiac surgery, coronary care unit, hospital teaching status, and ambulance use. OR indicates odds ratio.

We showed that the prescription rates for guideline-based medical treatments, such as angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, β blockers, and MRAs, were lower in the small numbers of cardiologists per cardiovascular beds groups, even after adjustment for patient and hospital characteristics. Guideline-based medical therapies led to better long-term outcomes for patients with HF, and are strongly recommended for the smaller numbers of cardiologists per cardiology beds groups.[18,19] We showed that the number of patients with HF per cardiologists was higher in the smaller number of cardiologists' groups than that in the larger number of cardiologists' groups, which may lead to heavy workload and reduce the quality of care.

In summary, our study showed that many cardiologists per cardiovascular beds leads to significantly reduced in-hospital mortality caused by acute HF, which was consistent with the results of past studies. It might be difficult to increase the absolute number of cardiologists soon; however, an alternative can be considered in terms of strategy for appropriate distribution of cardiologists among hospitals or the development of a better transportation system to appropriate hospitals for patients with HF, which may lead to improvements in the in-hospital outcomes and the quality of care for HF.

Study Limitations

Our study has several limitations. First, this was an observational study using the administrative database, which included ≈50% of Japanese Circulation Society–certified hospitals in Japan.[20] Second, the JROAD-DPC did not include detailed patients' characteristics, such as laboratory and physiological data. Third, we could not investigate the long-term mortality and accurate rehospitalization rates in this study. The prescription rates for medications and cardiac rehabilitation were higher in the larger numbers of cardiologists' groups, which may result in better long-term outcomes.

Conclusions

Patients with HF who were admitted to hospitals with larger numbers of cardiologists per cardiovascular bed were

Table 4. Adjusted In-Hospital Medical Treatments for Patients With HF

Group	Numbers of Cardiologists per 50 Cardiovascular Beds	β Blockers			ACE Inhibitors or ARBs			MRAs		
		OR	95% CI	*P* Value	OR	95% CI	*P* Value	OR	95% CI	*P* Value
First	0.63–5.7	1	Reference		1	Reference		1	Reference	
Second	5.8–8.2	1.09	0.97–1.22	0.15	1.04	0.92–1.17	0.54	0.97	0.87–1.08	0.59
Third	8.3–11.8	1.23	1.09–1.38	<0.001	1.03	0.91–1.16	0.62	1.08	0.97–1.21	0.17
Fourth	11.9–68.6	1.59	1.41–1.81	<0.001	1.38	1.20–1.58	<0.001	1.27	1.13–1.44	<0.001

Model includes age (per 10 years), sex, Charlson comorbidity index, Barthel index, New York Heart Association classification, hypertension, hyperlipidemia, diabetes mellitus, chronic kidney disease, atrial fibrillation, cardiac surgery, coronary care unit, hospital teaching status, and ambulance use. ACE indicates angiotensin-converting enzyme; ARB, angiotensin II receptor blocker; HF, heart failure; MRA, mineralocorticoid receptor antagonist; OR, odds ratio.

associated with lower in-hospital mortality and higher prescription rates for guideline-based treatments of HF.

Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. Hospital characteristics by category of cardiologist number per cardiovascular beds.

	Total	1st group	2nd group	3rd group	4th group	p
JCS-certified cardiologists per 50 cardiovascular beds						
Median (IQR)	8.3 (5.7-11.8)	4.4 (3.5-5.0)	6.7 (6.5-7.5)	9.7 (8.8-10.1)	16.7 (14.0-23.8)	
Range	0.63-68.6	0.63-5.7	5.8-8.2	8.3-11.8	11.9-68.6	
Number of hospitals (%)	770	201 (26)	177 (23)	203 (26)	189 (25)	
Emergent PCI/year	50 (26-89)	29 (12-46)	47 (25-74)	68 (38-103)	80.5 (43.5-122)	<.001
Planned PCI/year	132 (66-220.5)	65 (34-125)	106 (64-189)	144 (90-237)	201 (134-288)	<.001
CABG/year	23 (12-41)	11 (0-20)	23 (12-38)	22 (8-39)	33 (20-53)	<.001
Catheter ablation/year	2 (0-39)	0 (0-1)	0 (0-14.5)	4 (0-36)	60 (6-132)	<.001
Endomyocardial biopsy/year	1 (0-6)	0 (0-1)	1 (0-4)	2 (0-8)	5 (1-18)	<.001
Pacemaker implantation/year	26 (13-41)	15 (9-26)	22 (14-36)	30 (18-44)	39 (24-55)	<.001
CRT/year	0 (0-4)	0 (0-0)	0 (0-0.5)	0 (0-6)	6 (0-14)	<.001
TTE/year	3037 (1940-4920)	2098 (1400-2953)	2722 (1894-4129)	3305 (2182-4864)	5147 (3538-7323)	<.001

Coronary CT/year	200 (84-358)	120 (50-276)	182 (77-319)	211 (100-357)	294 (147-499)	<.001
Cardiac MRI/year	2 (0-21)	0 (0-3)	1 (0-8)	3 (0-17)	31 (2-81)	<.001
Cardiac RI/year	188 (78-384)	94 (24-197)	159.5 (54.5-261)	192 (91-410.5)	345 (178-556)	<.001
Cardiac rehabilitation/year	185 (77-369)	107 (34-103)	166 (69-284)	190 (77-383)	298 (158-485)	<.001

Continuous variables were expressed as median (IQR) for skewed distributed data. Kruskal-Wallis test was used to test for mean differences across groups. Categorical variables are presented as frequencies or percentages and were compared using the $\chi 2$ test.

JCS, Japanese Circulation Society; IQR, interquartile range; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; CRT, cardiac resynchronization therapy; TTE, Trans thoracic echocardiography; CT, computed tomography; MRI, magnetic resonance imaging; RI, radioisotope scintigraphy.