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ORIGINAL ARTICLE

Utilization of Intensive Care Units and Outcomes Based on Admission Wards in Cardiovascular Emergencies

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Background: Cardiovascular emergencies often require intensive care unit (ICU) management, but there is limited data comparing outcomes based on the admission ward.

Methods and Results: We analyzed data from the Japanese Registry of All Cardiac and Vascular Diseases Diagnosis Procedure Combination (JROAD-DPC) database (2016–2020) for 715,054 patients (mean age, 75.4±14.2 years, 58.4% male) admitted with acute myocardial infarction (N=175,974), unstable angina (N=45,308), acute heart failure (N=179,871), acute aortic dissection (N=58,597), pulmonary embolism (N=17,009), or post-cardiac arrest (N=184,701). Patients were categorized into 4 groups: intensive care add-ons 1/2, 3/4 (ICU 1/2, 3/4), high-care unit (HCU), and general wards. Comparisons included patient characteristics, hospitalization duration, mortality rates, and rates of defibrillation or cardiopulmonary resuscitation (CPR) defined by chest compression. General ward patients were the oldest and with shortest hospitalization durations. Additionally, mortality rates were the highest in general wards for acute heart failure, myocardial infarction, and aortic dissection. Defibrillation rates were 7.0%, 5.6%, 3.1%, and 4.3%, for ICU 1/2, 3/4, HCU, and general ward, respectively, with corresponding mortality rates of 40.4%, 44.1%, 44.6%, and 79.3%. CPR rates were 10.1%, 9.5%, 6.2%, and 30.8%, with mortality rates of 71.0%, 73.9%, 78.4%, and 97.7%, respectively.

Conclusions: High mortality rates in general wards highlight the importance of ICU management, particularly for acute myocardial infarction and aortic emergencies. These findings support prioritizing ICU admission for these critical conditions.

Key Words: Cardiac arrest; Cardiovascular diseases; Deaths; Intensive care units; Myocardial infarction

Cardiovascular diseases (CVDs) are a leading cause of morbidity and mortality worldwide, often requiring urgent medical intervention due to the potential for sudden deterioration.[1–4] Approximately 20 million deaths reported in 2021 and approximately 640 million people globally are living with heart and circulatory diseases.[5] Conditions such as acute myocardial infarction, unstable angina, acute heart failure, acute aortic dissection, pulmonary embolism, and post-cardiac arrest represent critical events that necessitate immediate and

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intensive medical care.[4,6] Traditionally, these acute cardiovascular events are managed in intensive care units (ICUs), where specialized monitoring and treatment, including rehabilitation, can be provided to improve patient outcomes.[7,8]

Despite the critical nature of these conditions, there is a notable gap in the literature regarding the incidence and management of sudden cardiovascular deterioration that occurs outside of ICUs, particularly in general wards.[9] General wards are typically not equipped with the same level of monitoring and rapid intervention capabilities as ICUs, which may result in poorer outcomes for patients experiencing acute cardiovascular events.[10]

The lack of comprehensive data on the frequency and outcomes of such acute deterioration while in general wards presents a significant challenge for healthcare systems. Understanding these dynamics is crucial for developing strategies to improve the management of CVD across different hospital settings. In this study we aimed to address this gap by analyzing data from the Japanese Registry of All Cardiac and Vascular Diseases Diagnosis Procedure Combination (JROAD-DPC) from 2016 to 2020.[11] By examining patient outcomes based on the level of care received, this research sought to elucidate the importance of ICU management for acute cardiovascular events and provide evidence to guide improvements in both healthcare policy and practice.

Methods

Study Design and Study Subjects

This was a retrospective analysis of the JROAD-DPC database, a comprehensive nationwide registry maintained by the Japanese Circulation Society (JCS). The database includes data from all participating training hospitals affiliated with the JCS. Diagnoses and comorbidities were classified using the International Classification of Diseases, 10th Revision (ICD-10).

From the JROAD-DPC database we identified patients admitted via ambulance transport with conditions such as acute myocardial infarction, unstable angina, acute heart failure, acute aortic dissection, pulmonary embolism, and post-cardiac arrest between January 2016 and December 2020. Patients were categorized into 4 groups based on their care setting: ICU with intensive care add-on 1/2 (ICU 1/2), ICU with intensive care add-on 3/4 (ICU 3/4), high-care unit (HCU), and general wards.[12] These categories were based on the Japanese medical reimbursement system, where "add-ons" refer to additional fees defined by the DPC framework.[13] The classification reflected the level of intensive care provided, with higher add-on codes corresponding to more resource-intensive care settings.

We compared patient demographics, including age, length of hospital stay (hospitalization duration), and in-hospital death (mortality rates), 1-day, 7-day, and 30-day in-hospital mortality rate. For acute myocardial infarction, comparisons were also made regarding the wards of hospitalization according to Killip classification and the corresponding mortality rates. Additionally, we analyzed the proportion of patients who underwent defibrillation or cardiopulmonary resuscitation (CPR), as defined by chest compression in this study, and their corresponding mortality rates across the 4 ward groups. Moreover, we examined the frequency and rate of defibrillation or CPR on each hospitalization during the first 7 days of admission across the wards.

Patient Involvement

No patient involvement was required in the development of the research question, outcome measures, study design, or implementation. There are no plans to involve patients in the dissemination of the study results.

Inclusion and Exclusion Criteria

We utilized the JROAD-DPC data to identify patients with CVDs. We included patients who were transported to the hospital via ambulance and excluded those who arrived without ambulance transport or those with unknown transport status.

Statistical Analysis

The level of statistical significance was set at $P<0.05$ (two-sided). Data are presented as mean±standard deviation for continuous variables and as percentages for categorical variables. Comparisons between groups were conducted using Student's t-test for normally distributed continuous variables and χ^2 test for categorical variables.

When comparing age, hospitalization duration, and mortality rates across wards, analysis of variance (ANOVA) was used, followed by adjustments with Tukey's post-hoc test.

Statistical analyses were conducted using SPSS Statistics software version 25 for Windows (IBM SPSS Statistics; IBM, New York, USA).

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. The JROAD-DPC database contains anonymized patient data with all personal identifiers removed through a standardized process.[14] Each participating hospital anonymized patients' IDs using hospital-specific code change equations before data submission.

The study protocol was approved by the Ethics Committee of Nippon Medical School (approval number: B-2022-517). The requirement for individual informed consent was waived due to the retrospective and anonymized nature of the data.[15]

Results

Ward Distribution of Admissions by Disease

We identified 1,306,635 patients with CVDs during the study period. Of them, 715,054 patients with ambulance

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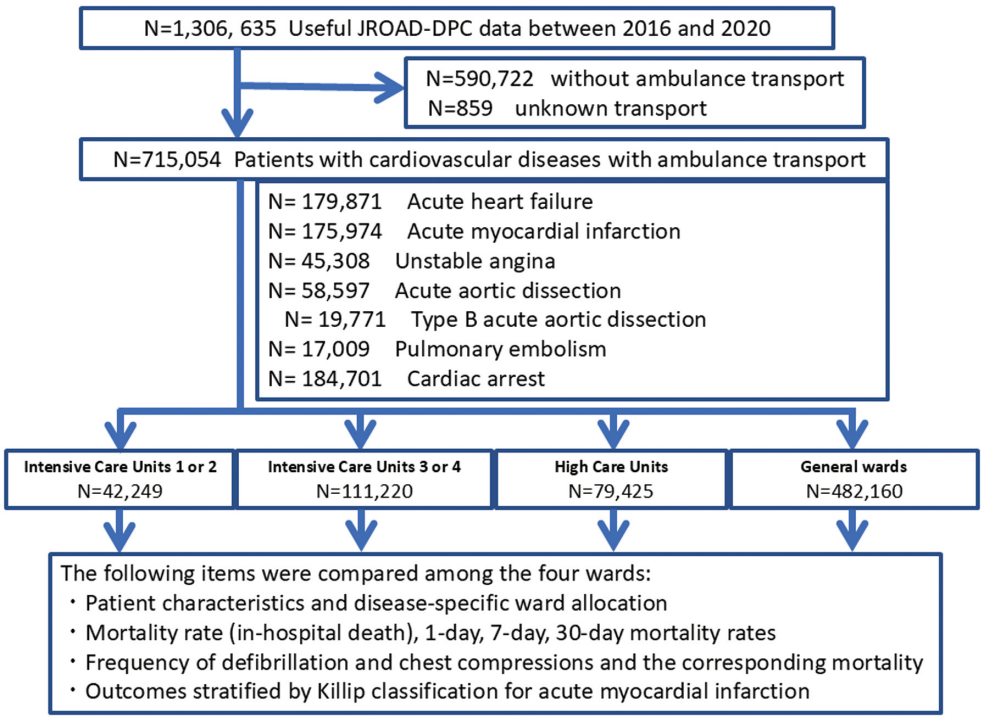

Figure 1. Flowchart of the study. JROAD-DPC, Japanese Registry of All Cardiac and Vascular Diseases Diagnosis Procedure Combination.

transport were enrolled in this study after excluding 590,772 patients without ambulance transport and 859 patients with unknown transport. The main causes of admission were acute heart failure (N=179,871), myocardial infarction (N=175,974), unstable angina (N=45,308), acute aortic dissection (N=58,597), including type B aortic dissection (N=19,771), pulmonary embolism (N=17,009), and post-cardiac arrest (N=184,701) (**Figure 1**).

The number of patients admitted to each of the 4 ward types was: 42,249 patients to ICU 1/2, 111,220 patients to ICU 3/4, 79,425 patients to HCU, and 482,160 patients to general wards. The proportion of patients admitted to each ward for each disease is shown in **Figure 2**. For acute myocardial infarction and acute aortic dissection including type B aortic dissection, >50% of patients were admitted to intensive care (ICU 1/2, ICU 3/4, or HCU). In contrast, approximately 30% of patients with acute heart failure, unstable angina, or pulmonary embolism, and only approximately 10% of those with post-cardiac arrest, were admitted to these units.

Patients' Characteristics and Mortality Rates Across the Wards

The mean age of the 715,054 study patients was 75.4±14.2 years, and 58.4% were male. The higher-care units, including ICU and HCU, admitted younger patients (ICU 1/2, 71.0±13.5 years; ICU 3/4, 71.8±13.4 years; HCU, 75.3±13.5 years; and general wards, 76.7±14.4 years, P<0.001 for each pair, ANOVA with Tukey's post-hoc method). The mean hospitalization duration among all the study patients was 18.0±18.0 days. Patients in the higher-care units stayed longer (ICU 1/2, 23.3±21.3 days; ICU 3/4, 21.2±19.9 days; HCU, 19.8±18.5 days; and general wards, 12.4±16.3 days; P<0.001 for each pair, ANOVA with Tukey's post-hoc method). The mortality rate among all the study patients was 34.2%. Patients in the higher-care units showed lower mortality (ICU 1/2, 16.5%; ICU 3/4, 16.0%; HCU, 14.4%; and general wards, 43.2%; P<0.05 for each pair, ANOVA with Tukey's post-hoc method) (**Table 1**). These findings indicated that patients in the general ward group were older, had shorter hospital stays, and worse outcomes compared with the other groups.

We compared in-hospital death (mortality rates), 1-day, 7-day, and 30-day in-hospital mortality rates across wards for the following groups: acute heart failure, myocardial infarction, and acute aortic dissection including type B aortic dissection. The results revealed that, for all these conditions, patients in the general ward had significantly worse outcomes across all metrics (ANOVA with Tukey's post-hoc method, P<0.05 for each pair) (**Figure 3**).

For acute myocardial infarction, comparisons regarding the wards of hospitalization according to Killip classification and the corresponding mortality rates are shown in **Table 2**. The rates of patients with acute myocardial infarction admitted to general wards and their respective outcomes in Killip classes I, II, III, and IV were as follows: 43.9% of Killip I patients, with a mortality rate of 3.0%; 42.1% of Killip II patients, with a mortality rate of 6.1%; 42.3% of Killip III patients, with a mortality rate of 17.6%; and 45.4% of Killip IV patients, with a mortality rate of 58.9%. These mortality rates in general wards were significantly higher than those in the higher-care units, especially in Killip classes II, III, and IV (ANOVA with Tukey's post-hoc method, P<0.05 for each pair). These findings indi-

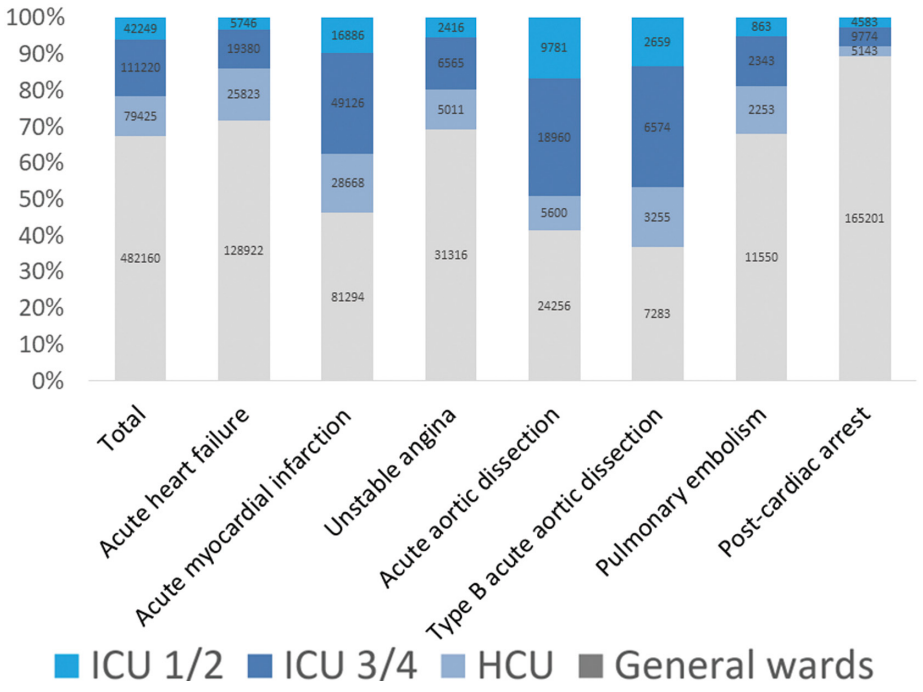

Figure 2. Ward distribution of admissions by disease. HCU, high-care unit; ICU 1/2, intensive care unit with intensive care add-on 1/2; ICU 3/4, intensive care unit with intensive care add-on 3/4.

Table 1. Patients' Characteristics by Ward Type and Prognosis

	No. of patients	Mean age (years)	Male	Hospitalization duration (days)	Mortality rate
Intensive care unit (1/2)	42,249	71.0±13.5	64.6%	23.3±21.3	16.5%
Intensive care unit (3/4)	111,220	71.8±13.4	65.0%	21.2±19.9	16.0%
High-care unit	79,425	75.3±13.5	60.0%	19.8±18.5	14.4%
General wards	482,160	76.7±14.4	56.0%	12.4±16.3	43.2%
Total	715,054	75.4±14.2	58.4%	18.0±18.0	34.2%

cated that patients with acute myocardial infarction admitted to general wards had significantly worse outcomes, particularly in higher Killip classes.

Frequency of Defibrillation or CPR and Their Corresponding Mortality Rates Across the Wards

The overall defibrillation rate was 4.5%, with a corresponding mortality rate of 66.3%. Among the ward groups, defibrillation was performed in 7.0% of patients in ICU 1/2, 5.6% in ICU 3/4, 3.1% in HCU, and 4.3% in general wards. The corresponding mortality rates were 40.4%, 44.1%, 44.6%, and 79.3% (**Table 3A**). Similarly, the overall frequency of CPR across all wards was 23.5%, with a corresponding mortality rate of 94.9%. When analyzed by ward group, CPR was performed in 10.1% of patients in ICU 1/2, 9.5% in ICU 3/4, 6.2% in HCU, and 30.8% in general wards. The corresponding mortality rates were 71.0%, 73.9%, 78.4%, and 97.7% (**Table 3B**). These results indicated that the general ward group had the highest mortality rate after defibrillation or CPR, reflecting worse outcomes compared with the higher-care units.

The frequency and rate of defibrillation or CPR on each hospitalization day during the first 7 days of admission across the wards are shown in **Figure 4**. The frequency of defibrillation or CPR was highest on the day of admission; however, these interventions remained frequent, particularly during the first 3 days of hospitalization. Even on the 7th day after admission, patients with CVDs were considered to still have a certain level of risk for sudden events such as cardiac arrest.

Frequency of Defibrillation or CPR in Acute Myocardial Infarction

For acute myocardial infarction, the frequency of defibrillation or CPR on each hospitalization day during the first 7 days of admission across the wards and among patients in Killip classes I–IV is shown in **Figure 5**. The frequency of both defibrillation and CPR was particularly high during the first 3 days and gradually decreased thereafter across all groups. However, even on the 7th day, both interventions were still observed even in the general wards, which is not low frequency. When analyzed by Killip clas-

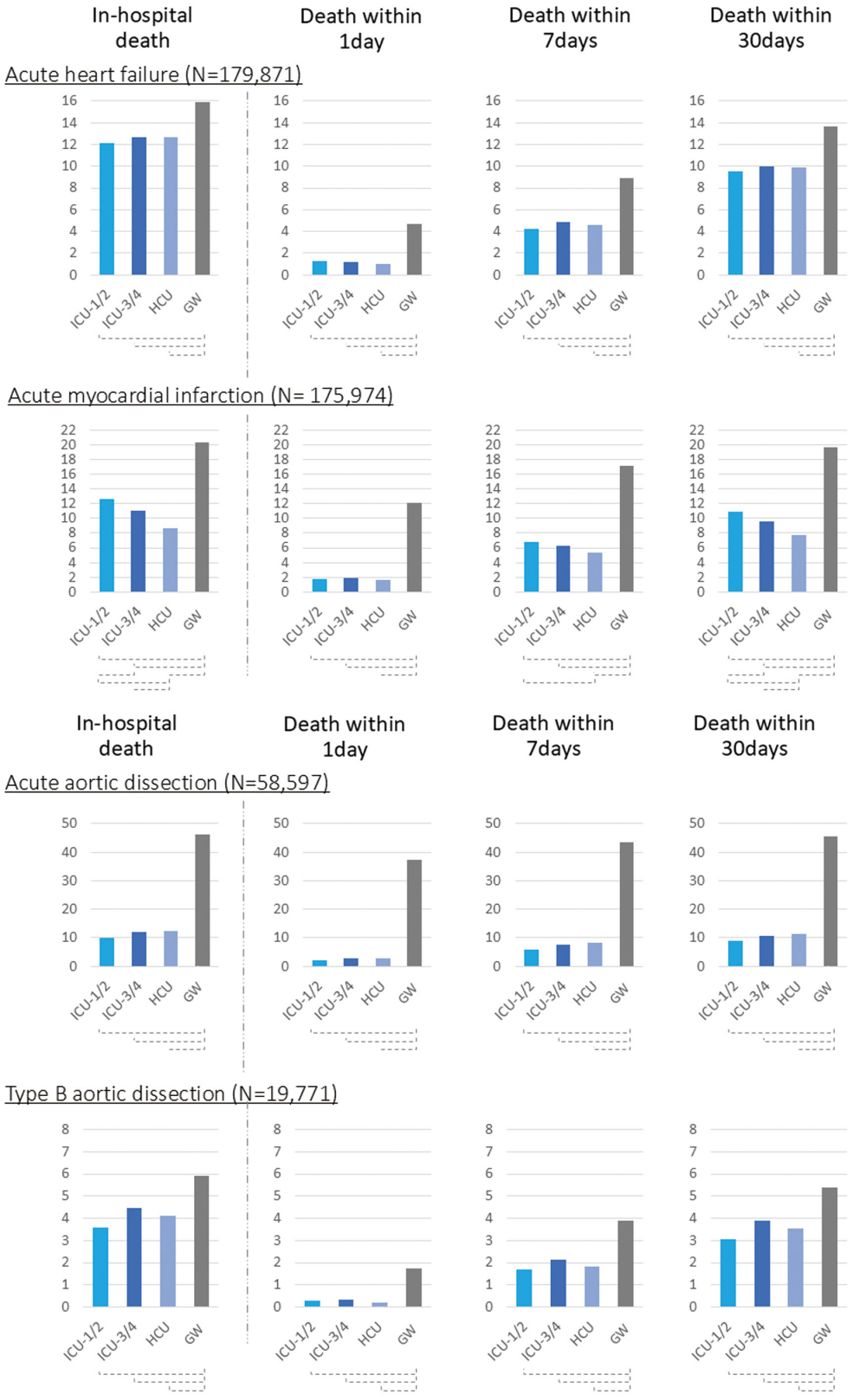

Figure 3. Comparison of mortality rates across wards for acute heart failure, acute myocardial infarction, and acute aortic dissection. The dotted lines indicate significant differences through ANOVA with Tukey's post-hoc method (P<0.05 for each pair). ANOVA, analysis of variance; GW, general wards; HCU, high-care units; ICU 1/2, intensive care unit with intensive care add-on 1/2; ICU 3/4, intensive care unit with intensive care add-on 3/4.

Table 2. Admission Ward and Mortality Rate of Patients With Acute Myocardial Infarction by Killip Classification

	Killip 1		Killip 2		Killip 3		Killip 4	
	N (rate)	Mortality	N (rate)	Mortality	N (rate)	Mortality	N (rate)	Mortality
ICU 1/2	7,098 (9.3%)	2.6%	3,355 (8.8%)	4.7%	1,794 (13.1%)	12.3%	3,344 (11.9%)	37.5%
ICU 3/4	22,667 (29.6%)	2.2%	10,990 (28.9%)	4.7%	3,721 (27.2%)	15.1%	8,558 (30.4%)	36.8%
HCU	13,211 (17.3%)	2.0%	7,673 (20.2%)	4.5%	2,371 (17.4%)	15.1%	3,472 (12.3%)	34.6%
General wards	33,580 (43.9%)	3.0%	15,985 (42.1%)	6.1%	5,772 (42.3%)	17.6%	12,776 (45.4%)	58.9%
Total	76,556	2.5%	38,003	5.2%	13,658	15.8%	28,150	46.7%

HCU, high-care unit; ICU 1/2, intensive care unit with intensive care add-on 1/2; ICU 3/4, intensive care unit with intensive care add-on 3/4.

Table 3. Frequency of Defibrillation or CPR by Ward Type and Prognosis

(A) Defibrillation	No. of patients	Defibrillation	Rate	Mortality rate with defibrillation	Mortality rate without defibrillation*
ICU 1/2	42,249	2,952	7.0%	40.4%	14.7%
ICU 3/4	111,220	6,178	5.6%	44.1%	14.4%
HCU	79,425	2,462	3.1%	44.6%	13.5%
General wards	482,160	20,566	4.3%	79.3%	41.6%
Total	715,054	32,158	4.5%	66.3%	32.7%
(B) CPR	**No. of patients**	**CPR**	**Rate**	**Mortality rate with CPR**	**Mortality rate without CPR***
ICU 1/2	42,249	4,247	10.1%	71.0%	10.4%
ICYU 3/4	111,220	10,525	9.5%	73.9%	10.0%
HCU	79,425	4,910	6.2%	78.4%	10.2%
General wards	482,160	148,667	30.8%	97.7%	18.9%
Total	715,054	168,349	23.5%	94.9%	15.5%

*Provided as a reference: these numbers represent the mortality rate of patients who did not undergo defibrillation or CPR. CPR cardiopulmonary resuscitation. Other abbreviations as in Table 2.

sification, patients in higher Killip classes (III and IV) had a higher frequency of defibrillation or CPR compared with those in lower classes (I and II), with Killip class IV patients exhibiting the highest frequencies, particularly on the first 3 days. These findings highlight the concentration of critical interventions in higher-care units and among patients in more severe Killip classes, particularly during the early days of hospitalization.

Discussion

This study, utilizing the JROAD-DPC database, demonstrated the outcomes for patients admitted via ambulance transport with CVDs, including acute heart failure, myocardial infarction, and acute aortic dissection. Patients admitted to general wards with CVDs had significantly higher mortality rates than those in higher-care units. A striking finding was that nearly half of patients with severe acute myocardial infarction (Killip class IV) were managed in general wards in Japan, despite significant mortality differences between general wards and higher-care units. Particularly concerning was the finding that mortality rates in general wards were consistently higher across all Killip classifications, with a notably high 58.9% mortality rate for Killip IV patients.

General wards lack sufficient monitoring and rapid response capabilities and this lack of specialized equipment and personnel may delay the initiation of life-saving interventions, contributing to poorer patient outcomes. This underscores the importance of ensuring that patients with severe cardiovascular conditions are promptly identified and transferred to higher-care units where they can receive the necessary level of treatment. An observational cohort study using a national administrative inpatient database for acute-care hospitals in Japan from 2011 to 2018 reported that the incidence of in-hospital cardiac arrest per 1,000 hospital admissions was 5.1.[16] However, in the present study, for cardiovascular emergencies the incidence of CPR was 23.5%, substantially exceeding the previous report. This finding emphasizes the critical nature of the initial hospitalization period and supports the preference for higher-care unit management whenever possible. These results provide compelling evidence for healthcare policy reform, particularly regarding resource allocation and the management of patients with cardiovascular emergencies.

Higher-care units play a pivotal role in the management of cardiovascular emergencies. This study showed that patients in ICUs, especially those with ICU add-ons, tend to be younger and have longer hospital stays, reflecting a more aggressive and comprehensive treatment approach. The higher rates of defibrillation or CPR observed in the ICUs, coupled with lower mortality rates, suggest that these units are better equipped to handle the complexities of cardiovascular emergencies. The availability of specialized staff and advanced medical technology in ICUs allows for more timely and effective interventions, which can significantly improve patient survival and recovery.[16]

The findings of this study have important implications for healthcare policy and resource allocation in Japan.

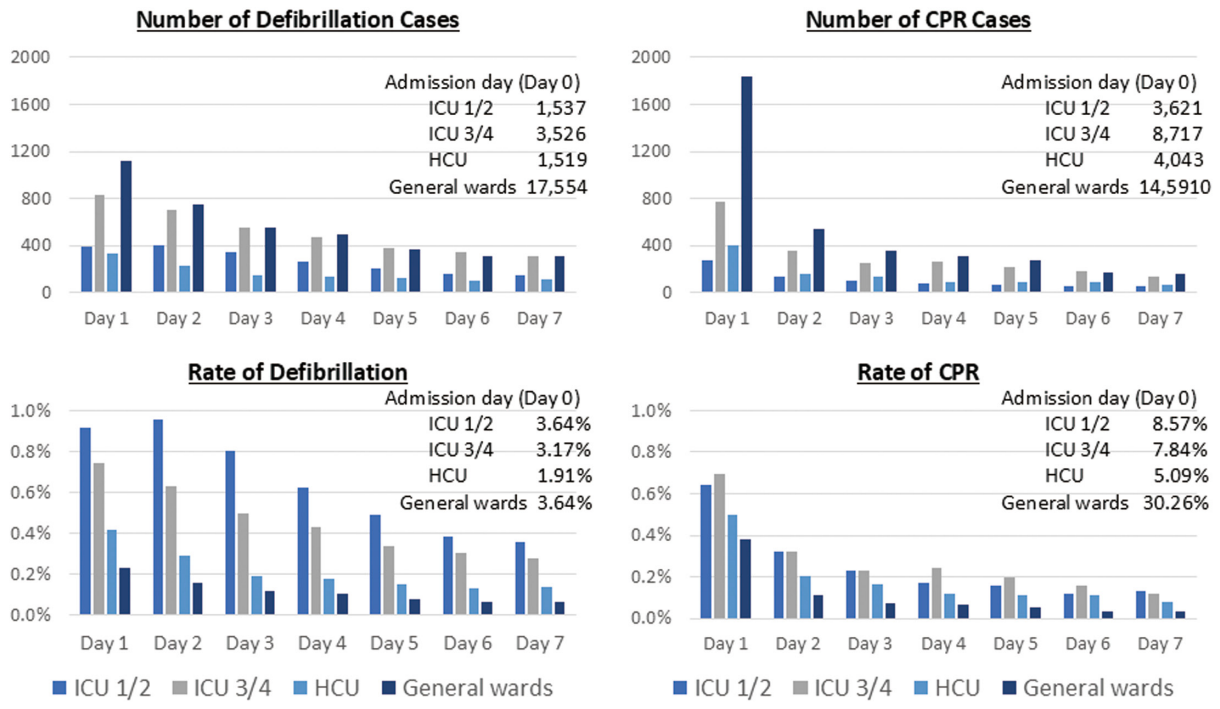

Figure 4. Daily frequency of defibrillation or cardiopulmonary resuscitation (CPR) during the first 7 days of admission across wards. The number of cases and the rate on the admission day (day 0) are separately indicated in text within the graph, as they are numerous. AMI, acute myocardial infarction; HCU, high-care unit; ICU 1/2, intensive care unit with intensive care add-on 1/2; ICU 3/4, intensive care unit with intensive care add-on 3/4.

There is a clear need for strategic planning to ensure that patients with cardiovascular emergencies are rapidly triaged and admitted to appropriate care settings.[17–19] This may involve increasing ICU capacity, enhancing the capabilities of general wards, or implementing systems to facilitate the swift transfer of patients to ICUs when necessary. Additionally, training programs for general ward staff on the early recognition and management of acute cardiovascular events could help bridge the gap in care quality between different hospital settings.[20]

Regarding the different mortality rates among the wards, it is possible that higher mortality rates in general wards might partially reflect more end-of-life care practices. In fact, the frequency of CPR on admission day was notably higher in general wards. However, the continued occurrence of CPR in the days following admission is typically not performed for end-of-life patients, which suggests ongoing acute treatment rather than a purely palliative situation. Moreover, the study's analysis of patients with acute myocardial infarction excluded those with post-cardiac arrest who were predominantly (90%) managed in general wards. This exclusion helped minimize the confounding effect of end-of-life care when comparing mortality rates.

A cohort study among patients with acute myocardial infarction showed that delayed in-hospital cardiac arrest (on or after hospital day 1) was associated with higher mortality rates, greater resource utilization, and lower discharge rates to home compared with early in-hospital cardiac arrest (hospital day zero).[21] The study results[21] suggested that prompt intervention through early intensive care for acute myocardial infarction may reduce in-hospital cardiac arrest and improve outcomes. Cardiogenic shock complicates 6–10% of ST-elevation myocardial infarction (STEMI) cases, with hospital mortality rates approaching 50%.[22] Although shock often develops early, it is typically not diagnosed at the time of hospital presentation.[22] In the SHOCK trial, among patients with STEMI who eventually developed shock during hospitalization, in approximately 50% it occurred within 6 h and in 75% within 24 h.[23] Therefore, the European Society of Cardiology (ESC) guidelines recommend that patients with STEMI be managed in coronary care units, which are comparable to ICUs in Japan, for a minimum of 24 h, and monitoring in a specialized bed for 48–72 h after admission is recommended.[24] However, the results of our study indicated that >40% of all acute myocardial infarction cases were managed in general wards. Notably, >45% of the patients with severe Killip class IV conditions were treated in general wards. These real-world data suggest that improvements in the management of acute myocardial infarction are needed in Japan.

While this study provides valuable insights, several limitations must be acknowledged. The retrospective nature of the analysis and reliance on registry data may not capture all aspects of patient care and outcomes. Additionally, the study cannot account for variations in care practices and resource availability across the wards. Future research should focus on prospective studies to validate that admission in higher-care units could improve outcomes and to explore interventions that could improve outcomes in gen-

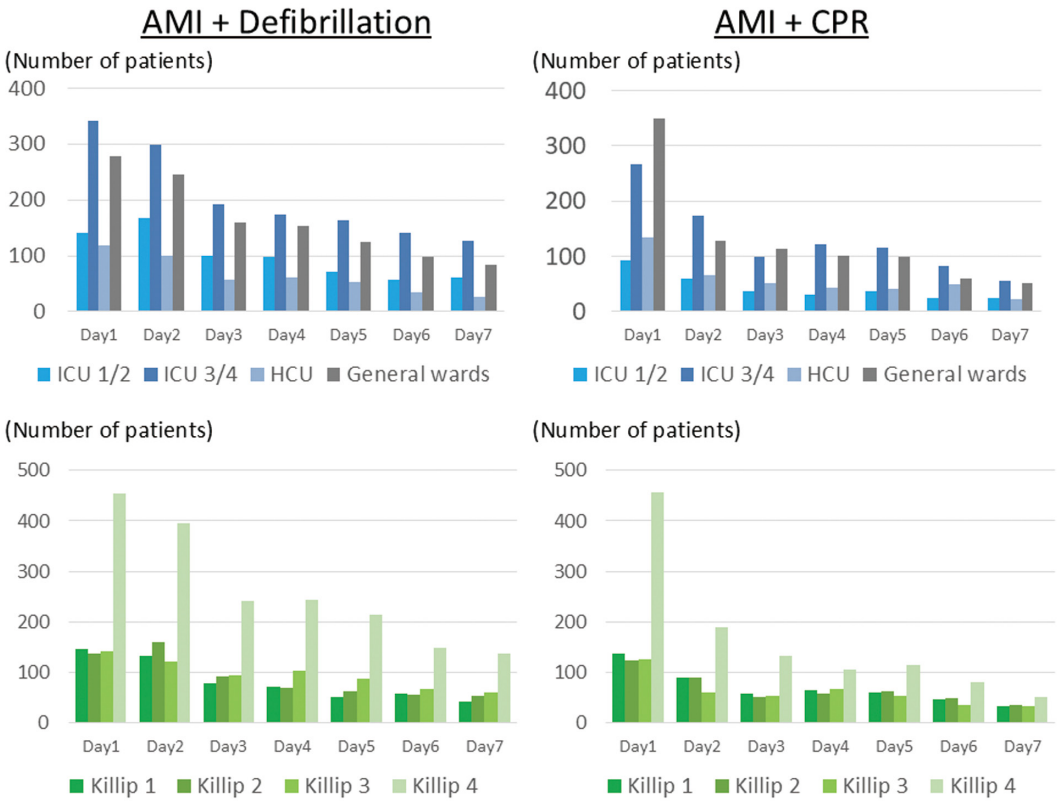

Figure 5. Daily frequency of defibrillation or cardiopulmonary resuscitation (CPR) during the first 7 days of admission across wards and Killip classes in patients with acute myocardial infarction; HCU, high-care unit; ICU 1/2, intensive care unit with intensive care add-on 1/2; ICU 3/4, intensive care unit with intensive care add-on 3/4.

eral wards. Investigating the potential benefits of telemedicine support,[25] rapid response teams,[2] and other innovative care models could provide further avenues for enhancing patient care.

The findings highlight the urgent need for healthcare systems to reassess their approach to managing acute cardiovascular events, focusing on appropriate care setting allocation and improving systems to address the limitations of general wards in handling these critical cases.

Conclusions

This study highlighted the critical importance of managing patients with cardiovascular emergencies in higher-care units. The significantly higher mortality rates in general wards, particularly among severe cases, underscore the need for improved resource allocation. These findings suggest that strategic improvements in hospital care settings could significantly enhance patient outcomes. By addressing the disparities in care quality across different types of wards, healthcare systems can better meet the needs of patients, ultimately reducing mortality rates and improving overall patient care. There is an urgent need for healthcare policy reforms aimed at optimizing care settings and outcomes for patients with cardiovascular emergencies.

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Disclosures

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IRB Information

This study received approval from the Ethics Committee of Nippon Medical School (approval number: B-2022-517).

Data Availability

The JROAD-DPC data used in this study can be obtained by applying to the JROAD Office of the JCS (Department of Information Use Promotion, National Cerebral and Cardiovascular Center). Access to the data is granted following review and approval. For more details, please visit the official website: https://www.j-circ.or.jp/jittai_chosa/about/summary/

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