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Systemic lupus erythematosus is associated with poor outcome after acute myocardial infarction

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KEYWORDS
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Abstract *Background:* Systemic lupus erythematosus (SLE) is associated with a higher risk of cardiovascular disease. However, it is not clear whether or not SLE is associated with poor outcomes after acute myocardial infarction (AMI).
Methods and results: Using the Taiwan National Health Insurance Database, we identified the SLE group as patients with AMI who have a concurrent discharge diagnosis of SLE. We also selected an age-, sex-, hospital level-, and admission calendar year-matched non-SLE group at a ratio of 1:3 from the total non-SLE group. One hundred fifty-one patients with SLE, 113,791 patients without SLE, and 453 matched patients without SLE were admitted with a diagnosis of AMI. Patients with SLE were significantly younger, predominantly female, and more likely to have chronic kidney disease than those without SLE. The in-hospital mortality rates were 12.6%, 9.0%, and 4.2% in the SLE, total non-SLE, and matched non-SLE groups, respectively. The in-hospital mortality was significantly higher in the SLE group than in the total non-SLE group (OR = 1.98; 95% CI = 1.2–3.26) and the matched non-SLE group (mortality OR = 2.20; 95% CI = 1.06–4.58). In addition, the SLE group was associated with a borderline significant risk of prolonged hospitalization when compared with the non-SLE group.
Conclusion: SLE is associated with a higher risk of in-hospital mortality and a borderline significantly higher risk of prolonged hospitalization after AMI.

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Introduction

Systemic lupus erythematosus (SLE) is an autoimmune inflammatory disease that involves many organs, including the cardiovascular system. The inflammation process of SLE induces premature atherosclerosis and vasculitis [1,2]. Many studies have reported a 2- to 10-fold higher cardiovascular risk in patients with SLE than in sex- and age-matched comparators [3–5]. The second peak of the bimodal mortality observed in patients with SLE is related to cardiovascular diseases such as coronary artery disease, acute myocardial infarction (AMI), or stroke. However, owing to the relatively low absolute event rate, it is difficult to evaluate the post-MI outcome of patients with SLE. To the best of our knowledge, three studies have investigated this issue, but the results were not consistent. In the study conducted by Ward et al. [6], there were no significant differences in the risk of in-hospital mortality and prolonged hospitalization between patients with SLE and those without SLE. However, in 2009, Shah et al. [7] reported that patients with SLE had a higher in-hospital mortality rate and prolonged hospitalization after AMI than patients without SLE. Another study conducted by Ando et al. [8] showed that the in-hospital mortality, length of hospitalization, and the hospitalization cost of acute coronary syndrome were similar between patients with SLE and those without SLE.

In Taiwan, a single-payer National Health Insurance (NHI) Program was launched in March 1995. In 2011, more than 98% of the 23 million residents of Taiwan were enrolled in this insurance program. Based on this program, the National Health Insurance Research Database (NHIRD) was established. We used this database to clarify whether patients with SLE have a poorer prognosis and a higher use of medical resources after AMI than those without SLE.

Methods

Study design

Our study used the NHIRD released by the Taiwan National Health Research Institutes. The NHIRD includes nationwide population-based data with high-quality controls and is available to scientists in Taiwan for research purposes. In this research, we conducted a population-based cohort study using administrative data from the Taiwan National Health Insurance Inpatient Database. This study was approved by the Institutional Review Board (IRB) of Taoyuan General Hospital, which has been certificated by the Ministry of Health and Welfare of Taiwan (IRB Approval Number: TYGH103015), and the protocol was evaluated by the National Health Research Institutes (NHRI), who agreed to the designed analysis of the NHIRD (Agreement Number: NHIRD-103-160). In this research, a dataset of inpatient expenditures by admissions, which included all inpatient data between January 1, 2002, and December 31, 2011, was analyzed. All patients who were admitted to hospital with a major diagnosis of AMI (admission ICD-9-CM code: 410) during this period were identified. Patients younger than 18 years of age were excluded from this study. For patients with more than one eligible admission, data from the first admission were selected for analysis. In this AMI patient group, we identified an SLE group as patients admitted with a concurrent discharge diagnosis of SLE (admission ICD-9-CM code: 710.0). Patients with AMI admitted without a diagnosis of SLE were identified as the non-SLE group.

The regulations of Taiwan's National Health Insurance Program define SLE as a catastrophic disease, and copayment for the treatment of SLE is fully covered. Regulations for the registration of SLE with the NHI program are strict and include the requirement for diagnosis by a certified rheumatologist and a review of medical records by the Bureau of NHI. Therefore, diagnoses of SLE in the NHI registry are reliable and accurate [9]. The validity of the diagnosis code of AMI in the NHIRD has been confirmed in a previous study [10].

We used the admission ICD-9-CM treatment codes to investigate the use of invasive cardiovascular procedures following admission, including percutaneous transluminal coronary angioplasty (PTCA; code numbers: 3601, 3602, 3605, and 3606), coronary stent deployment (code number: 3606), intra-aortic balloon pumping (IABP; code number: 3761), coronary artery bypass graft surgery (CABG; code numbers: 3610–3614), and extracorporeal membrane oxygenation (ECMO; code number: 3965). We also investigated the use of hemodialysis (code number: 39.95) and blood transfusion (code number: 99.0X) during admission. Additionally, the complications during admission were studied, including sepsis (code numbers: 995.91, 995.92, 790.7, and 785.52) and acute cerebrovascular event (code number 430–436). Data of the underlying comorbidities of the patients, including hypertension (ICD-9-CM: 401–5), dyslipidemia (ICD-9-CM: 272), previous cerebrovascular accident (ICD-9-CM: 431–8), diabetes mellitus (ICD-9-CM: 250), and chronic kidney disease (ICD-9-CM: 580–9), were also collected. The infarction territory was identified from the diagnosis ICD code, and it included the anterior wall (ICD-9-CM: 410.0 and 410.1), inferior wall (ICD-9-CM: 410.2–410.4), latero-posterior wall (ICD-9-CM 410.5–410.6), and other infarction sites (ICD-9-CM: 410.7–410.9).

The primary study endpoint was death during hospitalization, and the secondary study endpoints were length of admission and admission cost. To evaluate the risk of prolonged hospitalization, we created a dichotomous outcome of prolonged hospitalization, which was defined as a hospitalization period longer than the 75th percentile of the hospitalization period distribution of all patients with AMI. Another, more rigid, definition of prolonged hospitalization of a hospitalization period longer than the 90th percentile of the hospitalization period distribution was also used for analysis.

Propensity score matching analysis

As patients with SLE have been reported to be young and predominantly female, we conducted propensity score matching to derive subjects from the non-SLE comparison

group who were comparable to the SLE group subjects, thus reducing possible demographic differences. We calculated propensity scores for all patients with AMI and matched patients in the SLE group with those in the non-SLE control group at a 1:3 ratio depending on age, sex, calendar year of AMI admission, and hospital level of AMI admission (i.e., medical center, district hospital, or local hospital).

Statistical analysis

Descriptive statistics are represented as numbers of subjects, percentages, and means with standard deviation (SD). Differences in continuous values between two groups were assessed using independent t-tests, and significant differences in nominal variables were compared by χ^2 test. The odds ratios of patients with both SLE and AMI in terms of risk of mortality and prolonged hospitalization were calculated and adjusted using the logistic regression model. All data were stored and processed by the Hadoop Big Data distributed computing environment and analyzed using the Impala in-memory massively parallel processing (MPP) SQL query engine (Cloudera Corporation). Statistical analysis was performed using Statistical Package for the Social Sciences for Windows (SPSS Ver.18.0).

Results

During the study period, 151 patients with SLE and 113,791 patients without SLE were admitted with a diagnosis of AMI. The baseline characteristics of the patients with and without SLE are summarized in Table 1. Patients with SLE were significantly younger and more likely to be female

Table 1 Baseline characteristics, usage of invasive procedures, admission cost, and in-hospital mortality of the SLE group, non-SLE group, and matched non-SLE group.

	SLE group, n = 151	Non-SLE group, n = 113,791		Matched group, n = 453	
	N (%)	n (%)	p	n (%)	p
Age, mean (SD) (years)	53.1 (15.4)	66.8 (14.0)	0.001	53.1 (15.3)	0.98
Age group (years)					
19–24	2 (1.3)	98 (0.1)	<0.001	7 (1.6)	0.99
25–44	50 (33.1)	7179 (6.3)		144 (31.8)	
45–64	59 (39.1)	40,189 (35.3)		183 (40.4)	
> 65	40 (26.5)	66,299 (58.3)		119 (26.3)	
Sex					
Male	37 (24.5)	81,001 (71.2)	<0.001	114 (25.2)	0.87
Female	114 (75.5)	32,790 (28.8)		339 (74.8)	
Comorbidities					
Diabetes	11 (7.3)	34,780 (30.6)	<0.001	170 (37.5)	<0.001
Dyslipidemia	13 (8.6)	24,880 (21.9)	<0.001	129 (28.5)	<0.001
Stroke	5 (3.3)	6222 (5.5)	0.24	16 (3.5)	0.90
Chronic renal disease	37 (24.5)	10,261 (9.0)	<0.001	34 (7.5)	<0.001
Hypertension	51 (33.8)	43,724 (38.4)	0.24	178 (39.3)	0.23
Hospital level					
Medical center	100 (66.2)	51,661 (45.4)	0.96	302 (66.7)	0.96
Regional hospital	48 (31.8)	51,641 (45.4)		145 (32.0)	
District hospital	3 (2.0)	10,477 (9.2)		6 (1.3)	
AMI characteristics					
Anterior wall	37 (24.5)	26,490 (23.3)	0.58	105 (23.2)	0.57
Inferior wall	26 (17.2)	20,428 (18.0)		75 (16.6)	
Lateral posterior	5 (3.3)	2081 (1.8)		7 (1.6)	
Other	86 (57.0)	65,994 (58.0)		271 (59.8)	
Procedure and complications					
PTCA	86 (56.7)	57,568 (50.6)	0.12	245 (54.1)	0.54
Stent implantation	60 (39.7)	40,191 (35.3)	0.26	179 (39.5)	0.96
IABP	7 (4.6)	6399 (5.6)	0.60	19 (4.2)	0.82
ECMO	4 (2.7)	859 (0.8)	<0.01	5 (1.1)	0.18
CABG	8 (5.3)	4613 (4.1)	0.44	17 (3.8)	0.41
Hemodialysis	14 (9.3)	5189 (4.6)	<0.01	22 (4.9)	0.047
Blood transfusion	6 (4.0)	4749 (4.2)	0.90	14 (3.1)	0.60
Sepsis	2 (1.3)	368 (0.3)	0.03	1 (0.2)	0.095
Acute cerebrovascular event	3 (2.0)	1801 (1.6)	0.69	6 (1.32)	0.56
Hospitalization (mean/SD)					
Average medical cost (USD)	5809.3 (5023.9)	5088.0 (5019.5)	0.03	4858.9 (4561.7)	0.06
Median hospitalization duration (days)	7	6		6	
Average hospitalization duration (days)	11.5 (15.5)	8.6 (15.1)	0.01	7.9 (10.1)	0.01
Death in hospital	19 (12.6)	10,283 (9.0)	0.12	19 (4.2)	<0.01

AMI: acute myocardial infarction; SLE: systemic lupus erythematosus; CABG: coronary artery bypass graft surgery; ECMO: extracorporeal membrane oxygenation; IABP: intra-aortic balloon pumping; PTCA: percutaneous transluminal coronary angioplasty; SLE: systemic lupus erythematosus.

than patients without SLE. In addition, patients with SLE were less likely to have diabetes and dyslipidemia but more likely to have chronic kidney disease than the patients without SLE. With regard to the hospital level, patients with SLE were more likely to receive post-MI care in a medical center. The territory of myocardial infarction was similar in the two groups.

After propensity score matching, a total of 453 matched non-SLE patients were selected from the original non-SLE patient group. There were no significant differences in age, sex, hospital level, or territory of myocardial infarction between the SLE group and the matched non-SLE group. Compared with the matched patients without SLE, patients with SLE were still more likely to have chronic kidney disease and less likely to have diabetes and dyslipidemia (Table 1).

The usage of invasive procedures, admission cost, and in-hospital mortality is summarized in Table 1. Generally, more than 50% of patients with AMI received percutaneous coronary interventions, and approximately 30% of patients with AMI received coronary stent implantations. There were no significant differences in the rates of PTCA, coronary stent deployment, IABP, and CABG between the SLE group and the non-SLE group. Further, the ECMO rate was higher in the SLE group than in the non-SLE group (2.65% of patients with SLE and 0.75% of the total patients without SLE, $p = 0.007$), although ECMO cases were scarce. The hemodialysis rate was higher in the SLE group than in the non-SLE group (9.27% of patients with SLE and 4.56% of the total patients without SLE, $p = 0.006$). The rate of sepsis during admission was also higher in the SLE group than in the total non-SLE group (1.32% of patients with SLE and 0.32% of the total patients without SLE, $p = 0.03$). There were no significant differences in the crude mortality rate between patients with SLE and patients without SLE (12.6% in patients with SLE and 9.0% in all patients without SLE, $p = 0.129$). The medical costs were higher for patients with SLE than for patients without SLE (5809.3 USD for patients with SLE and 5088 USD for all patients without SLE, $p = 0.03$). The length of hospitalization in the different study groups is shown in Fig. 1, and it was longer for patients with SLE than those without SLE (median length: 7 days for patients with SLE and 6 days for patients without SLE, $p = 0.01$).

When comparing the SLE group and the matched non-SLE group, there were no significant differences in the rates of PTCA, coronary stent deployment, IABP, ECMO, and CABG (Table 1). The hemodialysis rate was higher in the SLE group than in the matched non-SLE group (9.27% of patients with SLE and 4.86% of the matched patients without SLE, $p = 0.047$). Patients with SLE were associated with a higher crude in-hospital mortality rate (12.6% in patients with SLE and 4.19% in matched patients without SLE, $p < 0.001$), a borderline higher medical cost (5809.3USD for patients with SLE and 4859 USD for matched patients without SLE, $p = 0.06$), and a longer hospitalization duration (median length: 7 days for patients with SLE and 6 days for matched patients without SLE, $p = 0.01$).

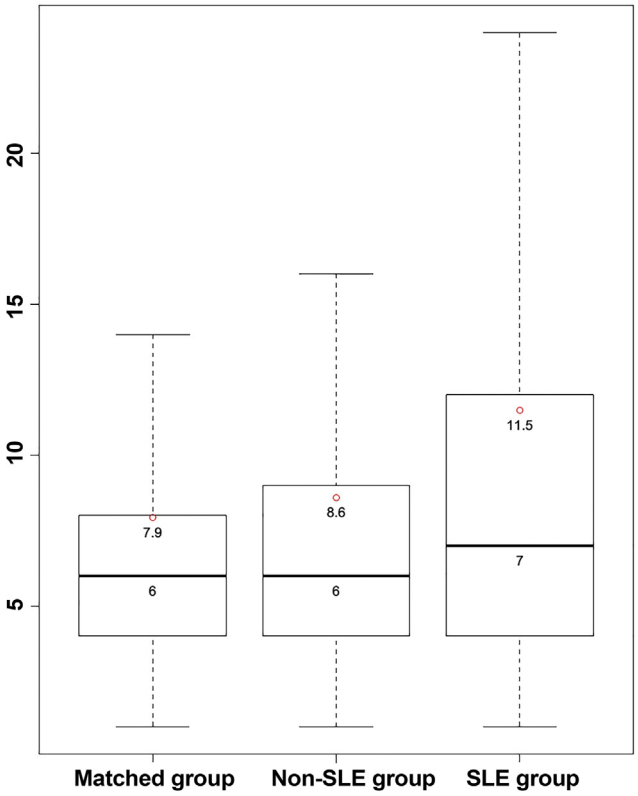


Figure 1 Distribution of the length of hospitalization in the three study groups. The horizontal line in the box represents the median hospitalization days, and the lower and upper edges of the box show the 25th and 75th quartiles, respectively. The upper and lower whiskers represent the largest and smallest non-outlier observed values, respectively.

The risks of in-hospital mortality and of prolonged hospitalization were further analyzed using multivariable logistic regression analysis, as shown in Table 2. Compared with all patients without SLE, patients with SLE had a non-significant higher crude risk of in-hospital mortality (OR = 1.45; 95% CI = 0.9–2.35). However, after adjusting for age, sex, diabetes, CKD, and hospital level, multivariable logistic regression analysis showed that patients with SLE had a significantly higher risk of in-hospital mortality (OR = 1.98; 95% CI = 1.20–3.26). When prolonged hospitalization was defined as longer than the 75th percentile of the hospitalization duration, patients with SLE were associated with a higher risk of prolonged hospitalization than those without SLE (OR = 1.47; 95% CI = 1.06–2.04). After multivariable logistic regression analysis, the SLE group still had a higher risk of prolonged hospitalization (adjusted OR = 1.49; 95% CI = 1.06–2.10). However, when we used the 90th percentile as the cutoff value of prolonged hospitalization, there were no significant differences in the crude and adjusted risks of prolonged hospitalization between the SLE and non-SLE groups (crude OR = 1.33; 95% CI = 0.86–2.06; adjusted OR = 1.31; 95% CI = 0.83–2.05).

Compared with the matched non-SLE patients, patients with SLE had a higher crude in-hospital post-MI mortality rate (OR = 3.29; 95% CI = 1.69–6.39) (Table 2). In the

Table 2 Risk of poor in-hospital outcome after acute myocardial infarction in the SLE group vs. total non-SLE group, and in the SLE group vs. matched non-SLE group.

SLE vs. total non-SLE	SLE group	Total non-SLE group	Univariable				Multivariable[a]			
	n = 151	n = 113,791	OR	95% CI		p	OR	95% CI		p
In-hospital mortality n (%)	19 (12.6)	10,283 (9.0)	1.45	0.90	2.35	0.13	1.98	1.20	3.26	<0.01
Prolonged hospitalization n (%)										
>75th percentile hospitalization	59 (38.6)	34,573 (30.4)	1.47	1.06	2.04	0.02	1.49	1.06	2.10	0.02
>90th percentile hospitalization	24 (15.7)	14,127 (12.4)	1.33	0.86	2.06	0.20	1.31	0.83	2.05	0.25
SLE vs. matched non-SLE	SLE group	Matched non-SLE group	Univariable				Multivariable[a]			
	n = 151	n = 453	OR	95% CI		p	OR	95% CI		p
In-hospital mortality n (%)	19 (12.6)	19 (4.2)	3.29	1.69	6.39	<0.01	2.20	1.06	4.58	0.04
Prolonged hospitalization n (%)										
>75th percentile hospitalization	59 (38.6)	123 (27.2)	1.72	1.17	2.53	<0.01	1.38	0.89	2.14	0.15
>90th percentile hospitalization	26 (17.0)	51 (11.3)	1.64	0.98	2.74	0.06	1.27	0.72	2.26	0.41

[a] Adjusted for age, sex, diabetes, kidney disease, dyslipidemia, and hospital level. SLE: systemic lupus erythematosus.

multivariable logistic regression model, the SLE group still had a significantly higher mortality risk than the matched non-SLE group (OR = 2.20, 95% CI = 1.06–4.58). When the 75th percentile was used as the cutoff value for prolonged hospitalization, the SLE group had a higher crude risk than the non-SLE group (OR = 1.72, 95% CI = 1.17–2.53). In the multivariate logistic regression analysis, there was no significant difference in the risk of prolonged hospitalization between the two groups. When we used the 90th percentile as the cutoff value of prolonged hospitalization, there were no significant differences in the crude or adjusted risks of prolonged hospitalization between the SLE group and the matched non-SLE group.

We performed subgroup analysis in the SLE and matched non-SLE groups, the results of which are shown in Table 3. SLE was significantly associated with a higher in-hospital mortality risk in patients aged >65 years, female patients, patients without diabetes, those who had received or not received PTCA, and patients with STEMI. Although not statistically significant, SLE was associated with a borderline higher mortality than that in other subgroups, such as younger patients (<65 years), male patients, and those with CKD.

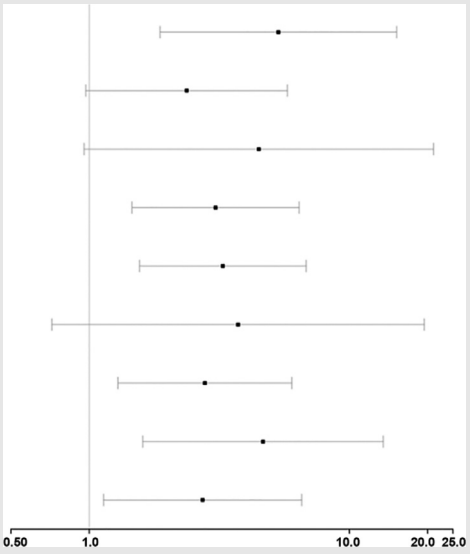
Discussion

In the present study, we compared the risk of in-hospital mortality, risk of prolonged hospitalization, and hospital care cost after AMI in patients with SLE and those without SLE. Our principal findings were as follows: (1) patients with SLE were associated with a higher in-hospital mortality rate after AMI than those without SLE, although the AMI territory and the usage of invasive interventions were similar; (2) patients with SLE were associated with a longer hospitalization duration and higher medical costs after AMI than those without SLE; (3) patients with SLE were associated with a nonsignificant higher risk of prolonged hospitalization after AMI than those without SLE.

Patients with SLE have been reported to have a higher risk of cardiovascular events than the general population. Traditional risk factors for cardiovascular diseases, such as smoking, diabetes, hypertension, and hyperlipidemia, have been reported to be more prevalent in patients with SLE who experience atherosclerotic vascular events than in those without atherosclerotic vascular events [11]. In addition to these traditional risk factors, the systemic and vascular inflammation associated with SLE can also accelerate the atherosclerotic process in the cardiovascular system [12]. However, whether these patients with SLE have a poor outcome after AMI is not known. Some risk measurements such as the TIMI risk score and the GRACE model have been developed to predict the risk of post-MI mortality [13]. The predictors in the risk measurements include age, heart rate, systolic blood pressure, creatinine level, diabetes, Killip classification, and anterior ST elevation. However, patients with SLE have premature atherosclerosis, and the age of the patient upon AMI attack has been found to be lower in patients with SLE than in the general population [3]. Using traditional risk scores to predict post-MI mortality in patients with SLE might lead to underestimation of the risk. Owing to the relatively low absolute event numbers in patients with SLE who suffer from AMI, it is difficult to collect an adequate amount of data from a single-center or multi-center registry [14]. To the best of our knowledge, three studies have evaluated the post-MI mortality risk in patients with SLE. The first used discharge data to evaluate the hospitalization outcome of patients with SLE after AMI and cerebrovascular accident in California [6]. In that study, prolonged hospitalization was defined as a hospitalization duration that exceeded the 90th percentile of stays for patients in the same diagnosis group in the Nationwide Inpatient Sample (NIS). The SLE group was found to be younger and had a higher Charlson Comorbidity Index than the comparison group. However, there were no significant differences in the risks of in-hospital mortality and prolonged hospitalization between patients with SLE and those without SLE. The second study, which took place in 2009 and used the US NIS database, enrolled more patients with SLE than the previous one. The definition of prolonged hospitalization in this second study was a stay longer than the 75th percentile of the distribution of length of hospital

Table 3 Mortality rates and relative risks of in-hospital mortality in different subgroups.

	SLE			Matched non-SLE			Mortality	Odds ratio (95%CI)
	Deaths	Patients	Mortality rate%	Deaths	Patients	Mortality rate%		
Age ≥65 years	10	40	25.00	7	119	5.88		5.333 (1.87, 15.19)
Age <65 years	9	111	8.11	12	334	3.59		2.36 (0.97, 5.78)
Male	4	37	10.81	3	114	2.63		4.485 (0.96, 21.06)
Female	15	114	13.16	16	339	4.72		3.059 (1.46, 6.41)
Non-DM	19	140	13.57	13	283	4.59		3.261 (1.56, 6.82)
CKD	7	37	18.92	2	34	5.88		3.733 (0.72, 19.41)
Non-CKD	12	114	10.53	17	419	4.06		2.782 (1.29, 6.01)
PTCA	9	86	10.47	6	245	2.45		4.656 (1.61, 13.50)
Non-PTCA	10	65	15.38	13	208	6.25		2.727 (1.13, 6.56)



The DM subgroup is not shown because there were no cases of mortality in the subgroup of DM and SLE. DM: diabetes mellitus; CKD: chronic kidney disease; PTCA: percutaneous transluminal coronary angioplasty; STEMI: ST-segment elevation myocardial infarction; NSTEMI: non-ST-segment elevation myocardial infarction.

stay. The researchers concluded that patients with SLE had higher risks of in-hospital mortality and prolonged hospitalization after AMI, and the risk was as high as that of the diabetic group [7]. However, in these previous studies, the type and territory of myocardial infarction were not mentioned. In addition, the use of invasive procedures such as percutaneous coronary intervention, CABG, and IABP was not fully reported. The conflicting results between the two studies implied that further investigation into outcomes after AMI in patients with SLE was required.

In the third study [8], Ando et al. used NIS database of the United States from 2005 to 2014 to investigate the post-MI outcomes in patients with SLE. In their study, they identified a total of 321,048 STEMI admissions, of which 1001 (0.31%) and 572,971 were NSTEMI admissions, of which 2134 (0.37%) were SLE admissions. They reported similar usage of revascularization strategies. There was no significant difference in hospital cost, hospital stay, and in-hospital mortality between the SLE and non-SLE groups. In contrast to the finding of the aforementioned study, our investigation showed a higher risk of in-hospital mortality and more medial cost in the SLE group when compared with that in the non-SLE group. Compared with the report of Ando et al. our study showed an SLE group with a younger age (53.1 years in our study and 58.6/61.2 years in the study of Ando et al.) and a higher mortality rate (12.6% in our study and 9.1%/4.1% in the study of Ando et al.). The usage of revascularization strategies was similar between the two studies. It is difficult to explain the different results between the two studies. Because our study population is mainly Asian, ethnic factor might partially explain the different results.

In our study, we used a national health insurance hospitalization database to evaluate all aspects of AMI in patients with SLE, including the AMI territory, use of invasive procedures, admission cost, and in-hospital mortality. Although the rates of anterior myocardial infarction and use of invasive treatments were similar, patients with SLE had poorer outcomes than non-SLE patients. There are a number of possible causes of the high post-MI mortality. First, patients with SLE have a higher prevalence of kidney disease. SLE is a multisystem disease, and lupus nephritis and chronic kidney disease are common complications of SLE [15]. In a systemic review focusing on the epidemiology of SLE in the Asia-Pacific region, the Asian group had a higher renal involvement rate than the white group. In addition, the main involved systems at the point of death in patients with SLE are the renal and cardiovascular systems [16]. Our study also disclosed that patients with SLE, although younger than the controls, had a high rate of chronic kidney disease. It has been reported that renal function impairment is an independent predictor of early death after an acute coronary event [17,18]. Furthermore, the coexistence of chronic renal disease and AMI implied a greater SLE disease severity. Therefore, chronic kidney disease is a possible cause and indicator of the high post-MI mortality in patients with SLE. Second, SLE is an inflammatory disease, and the inflammatory process is

associated with premature and unstable atherosclerotic plaques in the coronary arteries. In some case reports, patients with SLE presented with unusual coronary lesions such as aneurysmal dilatation or large thromboses [19,20]. Anatomic disorders would increase the difficulty in coronary intervention and may have a negative impact on post-MI mortality. In a study using the National Heart, Lung, and Blood Institute Dynamic Registry, Maksimowicz-McKinnon et al. [21] found that patients with SLE were more likely to receive repeated PCIs and experience an MI episode within one year of PCI. In another study, SLE was found to be an independent risk factor for post-CABG mortality and post-CABG revascularization [22]. The peri-procedural complication rate of the index PCI procedure was not significantly higher in the SLE group. In our study, the SLE group had a higher rate of ECMO usage than the non-SLE patients. Because ECMO implantation is indicated in patients with heart failure and cardiogenic shock, this implies that patients with SLE are associated with more common peri-procedure complications and cardiogenic shock in an AMI setting than those without SLE. However, owing to lack of details on coronary angiography procedures in the database, we were unable to confirm this hypothesis. Third, the rate of hemodialysis and sepsis was significantly higher in the SLE group than in the non-SLE group. This implies that the rates of complication including acute kidney injury and nosocomial infection might be higher in SLE group, and the higher complications could result in higher mortality in patients with SLE.

With regard to the risk of prolonged hospitalization, our findings were similar to those reported previously: when the 75th percentile was used as the cutoff point of prolonged hospitalization, SLE was associated with a higher risk of prolonged hospitalization; however, if the 90th percentile was used as the cutoff point, there was no significant difference in the risk of prolonged hospitalization between the SLE and non-SLE groups. As hospitalization duration longer than the 90th percentile may reflect the existence of more severe comorbidities and complications other than the autoimmune disease-associated acute coronary events, we postulated that SLE plays a minor role in cases of extremely prolonged hospitalization.

The high post-MI mortality rate in the SLE group implied that more intensive post-MI treatment is needed for this group. Some treatments such as high-intensity statin therapy, dual antiplatelet agents, and early invasive coronary intervention have been demonstrated to lead to a reduction in post-MI mortality in the general population. However, there is a lack of evidence of the effectiveness of these interventions in patients with SLE. According to the Lupus Atherosclerosis Prevention Study (LAPS), there were no significant differences in the progression of coronary artery calcium and the carotid intimal media thickness between those administered 40 mg of atorvastatin daily and those given a placebo [23]. In addition, patients with CKD were reported to receive fewer evidence-based therapies, such as aspirin, clopidogrel, and beta-blockers. The bleeding rate was also higher in the CKD group [18]. The high prevalence of chronic kidney disease in patients with SLE also makes standard therapy for AMI difficult. Moreover, some traditional risk factors such as hyperlipidemia, hypertension, and smoking addiction have been reported to be predictors of cardiovascular events in patients with SLE [24]. Aggressive control of these traditional risk factors in patients with SLE may decrease the risk of AMI. In addition, our report showed a higher rate of sepsis in the SLE group than in the non-SLE group. Early diagnosis and treatment for the nosocomial infection may improve the outcome of patients with SLE who suffer from AMI.

Our study had some limitations. First, we conducted the study using a nationwide administrative database, and some important predictors of post-MI mortality were not included in the data, such as blood pressure and heart rate at the emergency department, the door-to-balloon time if primary PTCA was performed, or the patient's body weight. Second, in our database, the disease duration and treatment given for SLE before AMI were not collected. Third, some misclassification might exist. Patients who expired after AMI might possibly have had more coded diagnoses including SLE, and this condition would overestimate the mortality risk of patients with SLE. Fourth, patients with AMI who died before admission were not included in our study. As a proportion of patients with AMI presented with sudden cardiac death, the post-MI mortality rate might be underestimated.

In conclusion, our study demonstrated that patients with SLE are associated with poor outcomes after AMI. This patient group should be regarded as a high-risk group, and further investigations into adequate post-MI treatment are needed for these patients.

Conflicts of interest

The authors have no funding, financial relationships, or conflicts of interest to disclose.

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