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Coronary Artery Disease

Clinical, Demographic, and Biochemical Characteristics of Patients with Acute ST-Segment Elevation Myocardial Infarction: An Analysis of Acute Coronary Syndrome Registry Data of a Single Medical Center from 2005 to 2016

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Background: ST-segment elevation myocardial infarction (STEMI) is one of the leading causes of morbidity and mortality in developed countries. Therefore, understanding the prevalence and trends of major risk factors may facilitate primary and secondary prevention of STEMI.

Methods: In the present study, 2446 consecutive patients with STEMI admitted to Far Eastern Memorial Hospital from 2005 to 2016 were enrolled. A comprehensive analysis of the prevalence, distribution, and trends over time of major risk factors as well as Framingham risk scores of all patients was performed.

Results: The most prevalent risk factors were male sex, hypertension (HTN), smoking, age, dyslipidemia, and diabetes mellitus. Furthermore, 95%-97% of the patients had at least one modifiable risk factor, and < 1% of the patients did not have any identifiable risk factors. The prevalence trends of smoking, HTN, dyslipidemia, and metabolic syndrome increased significantly from 2005 to 2016. Seasonal variation analysis revealed a 15% increase in STEMI cases between January and March compared with those between April and December. Isolated low high-density lipoprotein-cholesterol syndrome was the second most common type of dyslipidemia, with a prevalence rate of 16.6%. Moreover, only 56.8% of the male and 32% of the female patients were in the Framingham high-risk group.

Conclusion: A high prevalence rate and an increasing trend of modifiable risk factors resulted in a high number of STEMI cases at our hospital. Controlling modifiable risk factors and improving nontraditional risk factor detection could facilitate primary and secondary preventions for STEMI.

Key Words: Acute coronary syndrome registry • Far Eastern Memorial Hospital • Isolated low high-density lipoprotein syndrome • Major risk factors • ST-segment elevation myocardial infarction

INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) is one of the leading causes of morbidity and mortality in developed countries.[1] However, most studies on STEMI in Taiwan have exclusively reported the prevalence of major risk factors in the study population without analyzing all aspects.[2-5] Therefore, the aim of the present study was to comprehensively analyze these risk factors,

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including the prevalence and trends of the clinical, demographic, and biochemical characteristics of patients with STEMI.

MATERIAL AND METHODS

We analyzed the data of 2446 consecutive patients with STEMI from the Far Eastern Memorial Hospital (FEMH)-Acute Coronary Syndrome (ACS) registry from 2005 to 2016. The clinical, demographic, and biochemical characteristics of the patients were recorded at initial presentation. The distribution and trends over time of major risk factors such as age, sex, smoking, body mass index (BMI), hypertension (HTN), a history of diabetes mellitus (DM), and a history of dyslipidemia were analyzed. STEMI at a young age was defined as STEMI in men and women aged < 45 and < 50 years, respectively. Obesity, overweight, normal weight, and underweight were defined as BMI > 27, 24-27, 18.5-24, and < 18.5 kg/m^2, respectively.

Seasonal variations and distribution by month of the occurrence of STEMI were analyzed using data only from 2005 to 2015, as data from 2016 were not completely collected.

Framingham risk scores (FRSs) of all patients were calculated according to the formula published in the Framingham study (2008 version 3),[6] with an assumption of a systolic blood pressure of 130-140 mmHg. Framingham high-, moderate-, and low-risk groups were defined as patients having a possibility of coronary artery disease in 10 years of > 20%, 10%-20%, and < 10%, respectively. Lipid profiles were classified as hypercholesterolemia [cholesterol total (Cho-T) > 200 mg/dL or low-density lipoprotein-cholesterol (LDL-C) > 130 mg/dL and triglyceride (TG) < 200 mg/dL], hypertriglyceridemia (Cho-T < 200 mg/dl, LDL-C < 130 mg/dl, and TG > 200 mg/dL), mixed dyslipidemia (Cho-T > 200 mg/dL or LDL-C > 130 mg/dL and TG > 200 mg/dL), isolated low high-density lipoprotein-cholesterol (HDL-C) syndrome (Cho-T < 200 mg/dL, LDL-C < 130 mg/dL, TG < 200 mg/dL, and HDL-C < 35 mg/dL in men and < 45 mg/dL in women), and normal. Because of the unavailability of abdominal circumference data, modified criteria based on the international Diabetes Federation consensus worldwide definition[7] were used to define metabolic syndrome if at least three of the following five criteria were met: DM, HTN, BMI > 27 (which was used as a substitute for abdominal circumference), TG > 150 mg/dL, and HDL-C < 40 mg/dL for men and < 50 mg/dL for women.

Statistical analysis

Parameters are represented as means, medians, and standard deviations for continuous data and counts or percentages for categorical data. One-way analysis of variance was performed to examine the trends of means, and the Cochran-Armitage test was used to analyze the trends of categorical variables. The Cochran-Armitage test for trend is used in categorical data analysis when the aim is to assess the presence of an association between a variable with two categories and a variable with *k* categories. It is a method of directing the chi-squared test toward narrow alternatives. The test is sensitive to linearity between responsive variables and experimental variables, and can detect trends that would not be noticed by more crude methods.[8] Trend analysis was performed using SPSS (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY). All significance tests were two-sided, and $p < 0.05$ was considered to be statistically significant.

RESULTS

Table 1 shows the baseline characteristics of the patients. The mean age of the overall patient population was 58.98 $\pm$ 13.22 years. The most prevalent major risk factors were male sex (N = 2032, 83%), HTN (N = 1681, 68%), smoking (N = 1491, 61%), overweight and obesity (BMI > 25, N = 1117, 49%), dyslipidemia (N = 1165, 47%), and DM (N = 734, 30%). Only 13% of the overall population had been diagnosed with coronary artery disease (CAD) before STEMI presentation. Men aged 50-60 years (N = 702, 34%) and women aged 70-80 years (N = 115, 28%) comprised the highest proportions of the male and female patients, respectively (Figure 1).

Obese and overweight patients comprised 30% and 31% (N = 753 and 775, respectively) of the total study population. The male and female patients had a peak BMI of 24 kg/m^2. Only a small proportion (N = 70, 2.86%) of the study population was underweight (Table 2 and Figure 2).

Table 1. Baseline characteristics of the patients enrolled in the registry

Variables	Mean (SD), N (%)
Risk factors	
Age, years	58.98 (13.22)
Gender, male	2032 (83.07%)
BMI	25.42 (3.87)
Smoking	1491 (61.06%)
Hypertension	1681 (68.81%)
Dyslipidemia	1165 (47.67%)
Diabetes mellitus	734 (30.03%)
Known CAD history	319 (13.05%)
Creatinine, mg/dl	1.26 (1.33)
cho-T, mg/dl	181.25 (58.90)
TG, mg/dl	135.78 (132.38)
HDL-C, mg/dl	43.15 (13.47)
LDL-C, mg/dl	118.35 (42.10)
Uric acid, mg/dl	6.67 (3.26)
Family history	
AMI and CAD	136 (5.57%)

AMI, acute myocardial infarction; BMI, body mass index; CAD, coronary artery disease; Cho-T, cholesterol total; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SD, standard deviation; TG, triglyceride.

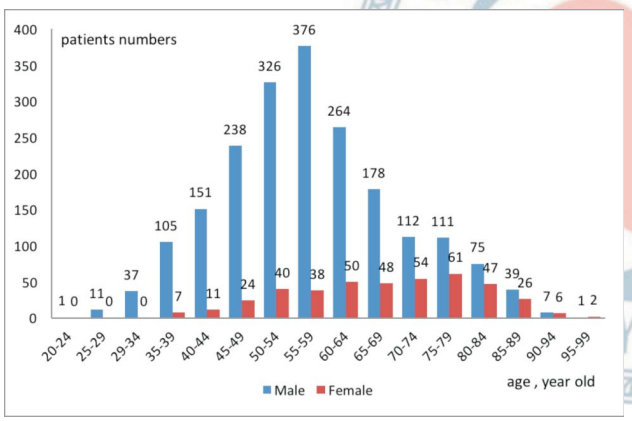

Figure 1. *Age distribution over time. Distribution of men (blue) and women (red) with ST-segment elevation myocardial infarction (STEMI) in the Far Eastern Memorial Hospital -Acute Coronary Syndrome (FEMH-ACS) registry. Men aged 50-59 years and women aged 70-79 years comprised the highest proportions of male and female patients, respectively.*

Dyslipidemia, including hypercholesterolemia, hypertriglyceridemia, and mixed dyslipidemia, was observed in 44% of the overall study population, and most patients (30.7%) had hypercholesterolemia. The prevalence of isolated low HDL-C syndrome, which has been rarely described in previous Taiwanese or Asian studies, was observed in approximately 16% of the overall study population (Table 3).

With regards to the Framingham risk groups, 56.8%, 27%, and 15% of the high-, moderate-, and low-risk groups of patients were male, compared to 32%, 47%, and 19% female patients, respectively. In addition, 97% of the male and 95.4% of the female patients had modifiable risk factors, whereas only 2.6% of the male and 3.62% of the female patients had non-modifiable risk factors. Very few male (0.34%) and female (0.97%) patients did not have any identifiable risk factors (Table 4).

Table 2. Body mass index distribution

BMI distribution	N (%)
≥ 27	753 (30.78%)
24-27	775 (31.68%)
18.5-24	778 (31.81%)
< 18.5	70 (2.86%)
NA	70 (2.86%)

BMI, body mass index; NA, not available.

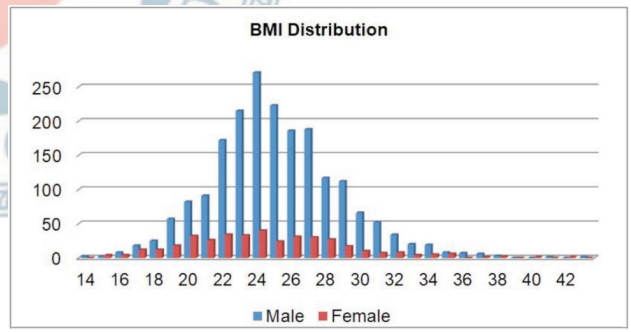

Figure 2. *Body mass index (BMI) distribution. Male and female patients had a peak BMI of 24.*

Table 3. Lipid profile distribution

Lipid profile analysis	N (%)
Hypercholesterolemia (Cho-T ≥ 200 mg/dl or LDL-C > 130 mg/dl, TG < 200 mg/dl)	751 (30.70%)
Hypertriglyceridemia (Cho-T < 200 mg/dl and LDL-C < 130 mg/dl, TG > 200 mg/dl)	143 (5.85%)
Mixed type (High Cho-T ≥ 200 mg/dl and High TG > 200 mg/dl)	210 (8.59%)
Isolated low HDL (Cho-T < 200 mg/dl, TG < 200 mg/dl, HDL-C < 35 mg/dl in male, HDL-C < 45 mg/dl in female)	408 (16.68%)
Normal lipid profile	816 (33.36%)

Cho-T, cholesterol total; HDL-C, high-density-lipoprotein cholesterol; LDL-C, low-density-lipoprotein cholesterol; TG, triglyceride.

Seasonal variations and distribution by month of the occurrence of STEMI are shownin Figure 3. There were more STEMI events from January to March. The number of STEMI cases increased by an average 16% per month during January-March (N = 602, 200/month) compared to April-December (N = 1549, 172/month) (Figure 3).

Table 5 shows the trends over time of major risk factors, including mean age and BMI, the prevalence of smoking, HTN, DM, dyslipidemia, and metabolic syndrome, and the proportion of STEMI at a young age. The trends over time of mean age and BMI and the prevalence of DM and STEMI at a young age were not significant. However, the prevalence of smoking, HTN, dyslipidemia, and metabolic syndrome increased significantly.

Table 4. Estimated Framingham risk score of all patients

FRS risk score	Male (N, %)	Female (N, %)
High CVD risk		
With MRF	1139 (56.05%)	134 (32.37%)
With NRF	17 (0.84%)	0 (0.00%)
Moderate CVD risk		
With MRF	538 (26.48%)	191 (46.14%)
With NRF	25 (1.23%)	7 (1.69%)
Low CVD risk		
With MRF	295 (14.52%)	70 (16.91%)
With NRF	11 (0.54%)	8 (1.93%)
Without any risk factors	7 (0.34%)	4 (0.97%)
Total		
With MRF	1972 (97.05%)	395 (95.41%)
With NRF	53 (2.61%)	15 (3.62%)
Without any risk factors	7 (0.34%)	4 (0.97%)

CVD, cardiovascular disease; MRF, modifiable risk factors; NRF, non-modifiable risk factors.

DISCUSSION

FEMH is located in New Taipei City and is a high volume center for percutaneous coronary interventions for

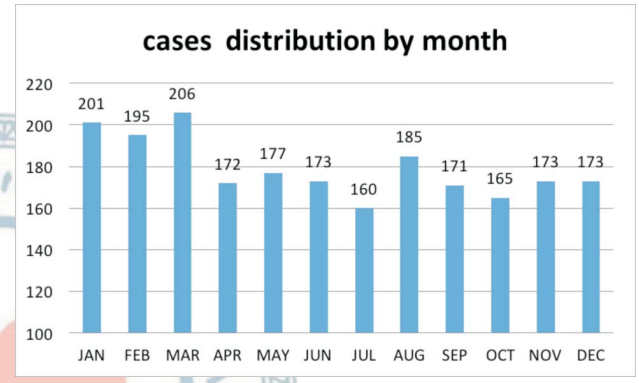

Figure 3. *Seasonal variation and distribution by month of ST-segment elevation myocardial infarction (STEMI) during 2005-2015. X-axis, month; Y-axis, number of cases. The average number per month of STEMI cases during January and March (200/ month) increased 16% compared to that during April and December (172/month).*

Table 5. Trends over time of the major risk factors

Year	Age	BMI	Smoking	HTN	DM	Dyslipidemia	AMI at young age	Metabolic syndrome	Total patients' number each year
	Mean (SD)		N (%)						
2005	59.77 (13.28)	24.99 (3.45)	80 (57.14%)	78 (55.71%)	56 (40.00%)	48 (34.29%)	17 (12.06%)	43 (30.50%)	140
2006	59.32 (13.24)	25.20 (3.82)	109 (55.33%)	108 (54.82%)	52 (26.40%)	53 (26.90%)	30 (15.23%)	44 (22.34%)	197
2007	60.06 (13.35)	24.97 (3.94)	106 (58.56%)	83 (45.86%)	55 (30.39%)	27 (14.92%)	22 (12.15%)	34 (18.78%)	181
2008	59.08 (14.02)	25.02 (3.58)	108 (57.14%)	111 (58.73%)	54 (28.42%)	37 (19.47%)	22 (11.52%)	54 (28.27%)	189
2009	58.97 (13.89)	25.50 (4.09)	110 (61.45%)	101 (56.11%)	51 (28.33%)	27 (15.00%)	26 (14.44%)	53 (29.44%)	179
2010	59.22 (13.12)	25.48 (3.97)	114 (61.62%)	109 (58.92%)	52 (28.11%)	51 (27.57%)	24 (12.97%)	57 (30.81%)	185
2011	58.62 (12.94)	25.35 (3.77)	129 (56.83%)	130 (57.27%)	65 (28.63%)	47 (20.70%)	34 (14.98%)	67 (29.52%)	227
2012	58.01 (12.91)	25.52 (4.07)	129 (55.84%)	164 (71.00%)	66 (28.57%)	77 (33.33%)	38 (16.45%)	81 (35.06%)	231
2013	58.98 (13.18)	25.36 (3.52)	140 (64.52%)	190 (87.56%)	71 (32.72%)	148 (68.20%)	34 (15.67%)	75 (34.56%)	217
2014	58.40 (13.70)	26.13 (4.14)	139 (67.48%)	192 (93.20%)	56 (27.18%)	193 (93.69%)	35 (16.99%)	90 (43.69%)	206
2015	58.65 (12.47)	25.83 (3.70)	128 (65.64%)	171 (87.69%)	60 (30.77%)	188 (96.41%)	25 (12.82%)	68 (34.87%)	195
2016	58.83 (13.03)	25.54 (3.73)	193 (68.68%)	235 (83.63%)	88 (31.32%)	266 (94.66%)	40 (14.23%)	108 (38.43%)	281
p-value	0.975	0.132	< 0.001	< 0.001	0.822	< 0.001	0.325	< 0.001	

AMI, acute myocardial infarction; BMI, body mass index; DM, diabetes mellitus; HTN, hypertension; SD, standard deviation.

ACS in Taiwan. The FEMH-ACS registry data comprises a significant portion of the Taiwan ACS full spectrum registry.[2,3] Compared with this registry, the FEMH-ACS registry had a higher prevalence of smoking (50.57% vs. 61%), HTN (56.3% vs. 68.8%), and dyslipidemia (33.1% vs. 47.67%). Moreover, during the last 4 years, the prevalence of smoking, HTN, dyslipidemia, and metabolic syndrome in our study increased significantly, particularly HTN and dyslipidemia. This increased prevalence may be partially associated with the definition of HTN and dyslipidemia and how they were reported in this study. The substantially increased influence of multiple modifiable risk factors may explain why FEMH is a high volume center for ACS in Taiwan.

In this study, 95% of the patients with STEMI had at least one major risk factor, and the overall prevalence rate of this study was high compared to reports from other international studies.[9-12] A few patients, most of whom were young and female,[4,13] did not have any identifiable risk factors. Therefore, nontraditional risk factors and biomarkers such as inflammation, oxidative stress, and endothelial dysfunction markers or environmental pollutants, should be evaluated for secondary screening of such patients to improve therapeutic efficacy and predict specific groups that are likely to benefit from targeted interventions.[14-18]

Seasonal variations with a higher incidence of myocardial infarction in the winter have been reported, however the results for STEMI have been conflicting.[19-21] Similar to most previous studies, our study demonstrated a higher incidence of STEMI in winter than in other seasons.

Substantial evidence has proven that low HDL-C levels are associated with an increased possibility of ACS.[22,23] The causes of low HDL-C are multi-factorial and include DM, hypertriglyceridemia, smoking, sedentary lifestyle, lack of exercise, obesity, a poor diet lacking unsaturated fatty acids, genetic factors and treatment with statins. However, because drug-induced HDL elevation does not provide any cardiovascular benefits,[24-26] isolated low HDL-C syndrome has received less attention, particularly compared with other types of dyslipidemia, and has been frequently less emphasized in clinical practice. In addition, Taiwanese studies have yet to address this syndrome. However, one study on Asia-Pacific populations suggested that this syndrome may be more prevalent (up to 22.4%) in Asian populations.[27-29] In our study, the prevalence of isolated low HDL-C syndrome was approximately 16.7%, which was second only to that of pure hypercholesterolemia and almost three times that of pure hypertriglyceridemia.[30,31] We were unable to explain the exact causes of the high prevalence rate of isolated low HDL-C syndrome in our population because all of the causes mentioned above were possible. Therefore, we suggest that this syndrome warrants further exploration. Furthermore, low HDL-C levels can be improved by exercise and polyunsaturated fatty acid-containing diets.[32-34] Regarding primary or secondary prevention of STEMI, interventions for HDL-C elevation are a future direction to minimize the risk of CAD.

Several studies have investigated the predictive accuracy or prediction power of the FRS.[35,36] In our study, 57% of the male patients with STEMI were classified in the high-risk group, compared to 43% in the moderate- and low-risk groups. Of the female patients with STEMI, only 34% were classified in the high-risk group, compared to 66% in the moderate- and low-risk groups. This finding may be because female patients tend to have a lower FRS according to the current formula, and because different pathophysiologic mechanisms such as chronic inflammation and microvascular dysfunction are not considered in the FRS.[37,38] To precisely predict the high risk of STEMI, a new scoring system encompassing other risk factors such as inflammation, oxidative stress, and endothelial dysfunction markers is required.

Study limitations

There are some limitations to the present study. First, this study used a database from a single center. Second, only patients who were successfully admitted to the hospital were enrolled in this registry, and patients who died at the emergency department were not enrolled. Third, some major risk factors such as HTN and the presence of dyslipidemia were not precisely recorded. Moreover, lipid profile can be influenced by medication, but medication histories before the onset of STEMI were usually not available. During the early years of this registry, HTN and dyslipidemia may have been under-diagnosed due to the patients being unaware of their condition. However, during the latter years of this registry, the extremely high prevalence of these two risk factors may have been due to loose criteria being ap-

plied by the physicians. Therefore, the trends over time of these two factors could have been influenced.

CONCLUSIONS

We comprehensively analyzed the prevalence and trends of current major risk factors. Most patients with STEMI had at least one modifiable risk factor and did not have a history of CAD. The prevalence of multiple modifiable risk factors, including smoking, HTN, dyslipidemia, and metabolic syndrome, has increased significantly in recent years. However, a considerable number of patients did not have a high FRS according to the current FRS formula. Furthermore, we reported the prevalence of isolated low HDL-C syndrome in patients with STEMI in Taiwan. To facilitate primary or secondary preventions of STEMI, several measures can be adopted, including improvements in lifestyle and dietary habits, the promotion of exercise, and the evaluation of non-traditional risk factors such as chronic inflammation, endothelial dysfunction, and oxidative stress markers.

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DECLARATION OF CONFLICT OF INTERESTS

All the authors declare that they have no conflict of interest. And this research received no grant from any funding agency in the public, commercial or not-for-profit sectors.

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