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ST-segment elevation myocardial infarction with non-chest pain presentation at the Emergency Department: Insights from the Singapore Myocardial Infarction Registry

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Abstract

ST-segment elevation myocardial infarction (STEMI) often presents acutely at the Emergency Department (ED). Although chest pain is a classical symptom, a significant proportion of patients do not present with chest pain. The impact of a non-chest pain (NCP) presentation on ED processes-of-care and outcomes is not fully understood. We utilised a national registry to characterise predictors, processes-of-care, and outcomes of NCP STEMI presentations. Retrospective data for all STEMI cases occurring between 2010 and 2012 were analysed from the Singapore Myocardial Infarction Registry. Cases of inpatient onset, inter-facility transfers, and out-of-hospital cardiac arrests were excluded. Univariable analysis of demographic, clinical, processes-of-care, and outcome variables was conducted. Multivariable logistic regression ascertained independent predictors of a NCP presentation and 28-day mortality. Of 4667 STEMI cases, 12.9% presented without chest pain. Patients with NCP presentation were older (median, years = 74 vs. 58; $p < 0.001$), more likely to be female (39.1% vs. 15.7%; $p < 0.001$), of the Chinese race (72.5% vs. 62.7%; $p < 0.001$), and with diabetes (48.6% vs. 36.7%; $p < 0.001$). These patients were more likely to present with syncope (6.0% vs. 1.9%; $p < 0.001$) or epigastric pain (10.6% vs. 4.9%; $p < 0.001$). Patients with NCP presentation were less likely to receive percutaneous coronary intervention (27.0% vs. 75.6%; $p < 0.001$), had longer door-to-balloon time (median, minutes = 83 vs. 63; $p < 0.001$), and experienced greater mortality at 28 days (31.2% vs. 4.5%; $p < 0.001$). On multivariable logistic regression, independent predictors of a NCP presentation included age (adjusted odds ratio [aOR] = 1.05, 95% confidence interval [CI] 1.04–1.07), diabetes (aOR = 1.76, 95% CI 1.40–2.19), BMI (aOR = 0.93, 95% CI 0.91–0.96), and dyslipidemia (aOR = 0.73, 95% CI 0.58–0.91). Absence of chest pain was an independent predictor for 28-day mortality (aOR = 3.46, 95% CI 2.64–4.52). Patients who presented with a NCP STEMI had a distinct clinical profile and experienced poorer outcomes. Routine triage ECG could be considered for patients with high-risk factors and non-classical symptoms.

Keywords ST-elevation myocardial infarction · Acute myocardial infarction · Atypical presentation · Painless · Chest pain · Door to balloon

Introduction

Cardiovascular disease is implicated as the principal cause of death in Singapore and exerts substantial morbidity [1]. The proportion of cardiovascular diseases as a cause of death has risen from 6.3% in the year 1950, to 31.3% in the year 2017 [1]. Acute myocardial infarctions (AMI) are an important subset of cardiovascular disease, and can be classified as either a non-ST-elevation myocardial infarction (NSTEMI) or a ST-elevation myocardial infarction (STEMI). In both instances, prompt recognition and treatment are crucial for optimal outcomes [2, 3]. As many patients with AMI present

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emergently at the Emergency Department (ED), accurate diagnosis offers the opportunity for timely and appropriate intervention.

While chest pain is a classical symptom of AMI, a significant proportion of patients with AMI do not present with chest pain [4]. Studies have suggested that the prevalence of non-chest pain presentations exceeds 20% of all patients eventually diagnosed to have an AMI [5–8]. Such patients were found in previous studies to present instead with symptoms of dyspnea, diaphoresis, or syncope, and were typically women, patients of advanced age, and with comorbidities such as hypertension and diabetes mellitus [4–12]. Non-chest pain presentations of AMI have also been associated with delayed hospital presentation, less aggressive treatment, and increased mortality [6–8]. Previous studies have utilised different methods to define the population of patients who present atypically, with many defining them by the absence of pain in any body region [11, 13]. This is opposed to the more clinically relevant absence of pain in the chest (non-chest pain STEMI presentation). As ED triage algorithms are predominantly chief complaint-oriented, and only certain chief complaints warrant a triage electrocardiogram (ECG), it is far more important to consider non-chest pain presentations of STEMI as a group. In addition, several studies that were done at a hospital or regional level may not have had the generalizability of results afforded by a national level registry [5–7, 10–12].

We thus aim to characterise the presentations, predictors, processes-of-care, and outcomes of patients with STEMI who present without chest pain in Singapore, with a focus on patients who present at the ED. Data from a national AMI database will be utilised.

Methods

Study setting and design

Singapore is a city-state with a total land area of 723 km^2 and a population of 5.6 million people (population density: 7800 people/km^2) [14]. Highly urbanized and interconnected, the nation is served by nine public and eight private hospitals equipped with modern emergency departments [15]. Emergency medical services (EMS) are managed by the Singapore Civil Defence Force (SCDF), a nation-wide centralised command that dispatches ambulances in response to calls made to an emergency hotline number. In 2017, 88.9% of EMS calls were attended to within 11 min [16], with patients sent to the nearest public hospital. Between 2010 and 2012, 49.8% of STEMI patients presented to the hospital via EMS [17].

Mandatory notification of all cases of AMI was enacted under the National Registry of Diseases Act for public hospitals in 2007, with extension to private hospitals in 2012 [18]. Reporting includes a small proportion of AMI cases occurring in homes that are certified by medical practitioners. Information for each case of AMI is collected and stored in the national level Singapore Myocardial Infarction Registry (SMIR), housed under the National Registry of Diseases Office (NRDO) [19].

Study population

Sources of data utilised for AMI identification by the SMIR included inpatient discharge summaries, laboratory data, medical claims, and the national death registry [20]. For each case of AMI, registry coordinators extracted detailed patient data for entry into SMIR. Quality assurance included a logic check, where illogical data or outliers were flagged for review. Yearly internal audits were done to ensure inter-rater reliability of at least 95%.

An AMI was defined as either a definitive AMI (definite ECG changes, or clinical symptoms and abnormal cardiac enzymes with probable ECG changes, or typical symptoms and abnormal cardiac enzymes where ECG was unavailable), clinical AMI (suggestive ECG changes of AMI but unsupported by typical symptoms or abnormal cardiac enzymes, or any two of the following three criteria: prolonged chest pain of more than 20 min, abnormal cardiac enzymes, or suggestive ECG changes), or death cases signed up with AMI as the cause of death [20]. Recurrence of AMI after 28 days of the initial event was counted as a separate episode in accordance with MONICA criteria [21]. STEMI was defined by typical chest pain lasting at least 20 min, accompanied by ST-elevation (0.1 or 0.2 mV rise in two adjacent limb or precordial leads, or new left bundle branch block) and subsequently corroborated with raised cardiac enzymes.

Selection of participants

De-identified data of all cases of STEMI recorded in the SMIR between January 2010 and December 2012 were analysed. STEMI cases diagnosed between 2010 and 2011 were identified by International Classification of Diseases 9th Revision (ICD-9 Clinical Modification) code 410, while STEMI cases diagnosed in 2012 were identified by ICD-10 codes I21 and I22. Inpatient cases were excluded due to likely differences in etiology compared to cases presenting at the ED, with noncomparable process-of-care timings. Inter-facility transfers were similarly excluded for noncomparable process-of-care timings. As STEMIs resulting in out-of-hospital cardiac arrests would have different resuscitation and treatment priorities, they were also excluded from analysis.

Statistical analysis

Statistical analysis was performed using STATA SE (version 13) software. STEMI cases were classified into two comparator groups, those presenting with or without chest pain. We reported the baseline characteristics, clinical presentation, treatment received, process-of-care timings, and patient outcomes. Continuous variables were presented as median (range) and compared between groups with the Mann–Whitney *U* test, while categorical variables were presented as number (percentage) and compared between groups with the Pearson's Chi-squared test or Fisher's exact test as appropriate. Multivariable logistic regression was conducted to ascertain independent variables predictive of a non-chest pain STEMI presentation, door-to-balloon time beyond 60 min, and death within 28 days from the onset of STEMI. All presenting variables relating to patient baseline characteristics and clinical parameters were initially included for multivariable analysis. Backward elimination of variables in a stepwise manner was subsequently performed to keep the multivariable models parsimonious. Statistical significance was set at a p value ≤ 0.05.

Results

Study population

A total of 6412 cases of STEMI were identified. 1745 cases were excluded as they were inter-facility transfers, inpatient onset, or case leading to a cardiac arrest. Of the final 4667 cases, 603 (12.9%) presented without chest pain. A population flow diagram is presented in Fig. 1.

Baseline demographics and clinical presentation

Table 1 displays the demographic and clinical characteristics of the study population.

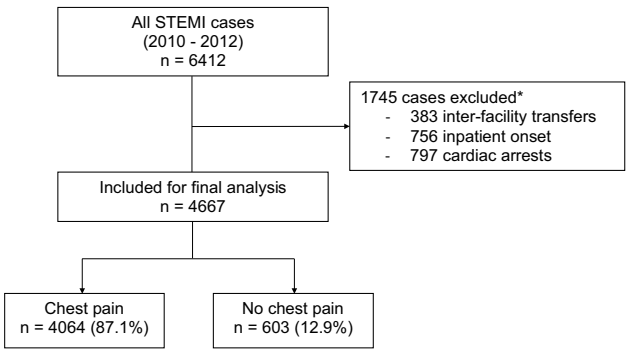

Fig. 1 Population flow diagram. *STEMI* ST-elevation myocardial infarction. *Cases are not mutually exclusive

Patients without chest pain were almost 2 decades older (median age in years = 74 vs. 58, $p < 0.001$), more than twice as likely to be female (39.1% vs. 15.7%), and with higher rates of diabetes mellitus (48.6% vs. 36.7%, $p < 0.001$). They also had an increased likelihood of having had a previous AMI (18.2% vs. 12.3%, $p < 0.001$), but were half as likely to have a previous history of coronary intervention (5.7% vs. 10.1%, $p = 0.001$).

On presentation at the ED, patients without chest pain were three times as likely to present with syncope (6.0% vs. 1.9%, $p < 0.001$), and twice as likely to present with epigastric pain (10.6% vs. 4.9%, $p < 0.001$). They were less likely to present with textbook findings of dyspnea (53.4% vs. 60.2%, $p = 0.002$), diaphoresis (24.0% vs. 69.3%, $p < 0.001$), jaw pain (0.8% vs. 5.5%, $p < 0.001$), or shoulder pain (2.2% vs. 6.6%, $p < 0.001$). Killip scores for non-chest pain presentations were higher across all classes (class 1 = 62.9% vs. 84.3%; class 2 = 12.8% vs. 6.7%; class 3 = 12.1% vs. 4.3%; class 4 = 12.3% vs. 4.8%; $p < 0.001$). Differences in rates of EMS utilization were not significant between groups (61.5% vs. 49.4%, $p = 0.144$).

Patients without chest pain were more likely to have anterior STEMI (57.5% vs. 51.7%, $p = 0.008$), lateral STEMI (39.5% vs. 35.0%, $p = 0.033$), and left bundle branch blocks (1.2% vs. 0.2%, $p < 0.001$) on ECG. Laboratory findings demonstrated non-chest pain STEMI patients to have lower hemoglobin (median hemoglobin in g/dL = 12.9 vs. 14.6, $p < 0.001$), worse renal function (median creatinine in μmol/L = 109.0 vs. 87.0, $p < 0.001$), and a more modest increase in cardiac enzymes as compared to chest pain presentations (peak troponin T in μg/L = 1.3 v. 3.8, $p < 0.001$; mean CK-MB in μg/L = 15.4 vs. 70.5, $p < 0.001$).

Treatment received, process-of-care timings, and outcomes

Table 2 displays the treatment received, process-of-care timings, and outcome variables of the study population.

Non-chest pain STEMI patients were less likely to receive goal-directed medical therapy. They were less likely to be started on aspirin (98.2% vs. 99.9%, $p < 0.001$) or antiplatelet therapy (96.4% vs. 99.6%, $p < 0.001$) within the first 24 h, and three times less likely to receive primary percutaneous coronary intervention (27.0% vs. 75.6%, $p < 0.001$). The proportion of patients who achieved a door-to-balloon time under 90 min was decreased in the group that presented without chest pain (60.1% vs. 79.7%, $p < 0.001$), although they had a shorter symptom-to-door timing (median time in minutes = 102 vs. 148, $p < 0.001$).

During their inpatient stay, patients with non-chest pain presentations were more likely to experience complications such as a complete heart block (4.6% vs. 2.7%, $p = 0.006$), arrhythmias (24.5% vs. 20.7%, $p = 0.025$), acute renal failure

Table 1 Baseline characteristics and clinical parameters among patients with STEMI

	Chest pain ($n=4064$, 87.1%)	No chest pain ($n=603$, 12.9%)	p value
Age in years, median (range)[a]	58 (21–102)	74 (21–100)	<0.001
Gender, *n* (%)[a]			<0.001
Male	3427 (84.3)	367 (60.9)	
Female	637 (15.7)	236 (39.1)	
Race, *n* (%)[a]			<0.001
Chinese	2550 (62.7)	437 (72.5)	
Malay	848 (20.9)	105 (17.4)	
Indian	606 (14.9)	53 (8.8)	
Others	60 (1.5)	8 (1.3)	
BMI in kg/m^2, median (range)[a]	24.5 (12.6–47.1)	22.3 (12.3–43.4)	<0.001
Smoking status, *n* (%)[a]			<0.001
Current	1978 (49.0)	141 (24.5)	
Ex-smoker	558 (13.8)	92 (16.0)	
Never	1500 (37.2)	342 (59.5)	
Past medical history, *n* (%)			
Hypertension[a]	2212 (54.5)	413 (68.9)	<0.001
Diabetes mellitus[a]	1491 (36.7)	291 (48.6)	<0.001
Dyslipidemia[a]	2549 (62.8)	331 (55.3)	<0.001
AMI[a]	501 (12.3)	109 (18.2)	<0.001
CABG	61 (1.5)	6 (1.0)	0.338
PTCA/PCI[a]	408 (10.1)	34 (5.7)	0.001
EMS utilisation, *n* (%)	2007 (49.4)	371 (61.5)	0.144
Presenting symptoms, *n* (%)			
Dyspnea[a]	2446 (60.2)	322 (53.4)	0.002
Diaphoresis[a]	2818 (69.3)	145 (24.0)	<0.001
Syncope[a]	77 (1.9)	36 (6.0)	<0.001
Back pain[a]	356 (8.8)	27 (4.5)	<0.001
Epigastric pain[a]	198 (4.9)	64 (10.6)	<0.001
Jaw pain[a]	222 (5.5)	5 (0.8)	<0.001
Shoulder pain[a]	269 (6.6)	13 (2.2)	<0.001
ECG diagnosis, *n* (%)			
Anterior[a]	2102 (51.7)	347 (57.5)	0.008
Posterior[a]	513 (12.6)	53 (8.8)	0.007
Inferior[a]	1841 (45.3)	222 (36.8)	<0.001
Lateral[a]	1423 (35.0)	238 (39.5)	0.033
LBBB[a]	8 (0.2)	7 (1.2)	<0.001
Right ventricular	227 (5.6)	28 (4.6)	0.342
Cardiac enzymes, median (range)[b]			
Peak troponin T in µg/L[a]	3.8 (0.003–60.4)	1.3 (0.006–90.0)	<0.001
Mean CK-MB in µg/L[a]	70.5 (0.7–1000.0)	15.4 (1.0–509.8)	<0.001
Creatinine in µmol/L, median (range)[a]	87.0 (12.0–1348.0)	109.0 (24.0–1537.0)	<0.001
Hemoglobin in g/dL, median (range)[a]	14.6 (4.5–20.0)	12.9 (5.3–19.1)	<0.001
Killip score, *n* (%)[a]			<0.001
Class 1	3426 (84.3)	379 (62.9)	
Class 2	271 (6.7)	77 (12.8)	
Class 3	173 (4.3)	73 (12.1)	
Class 4	194 (4.8)	74 (12.3)	

AMI acute myocardial infarction, *BMI* body mass index, *CABG* coronary artery bypass grafting, *CK-MB* creatine kinase-muscle/brain, *ECG* electrocardiogram, *EMS* emergency medical services, *LBBB* left bundle branch block, *PCI* percutaneous coronary intervention, *PTCA* percutaneous transluminal coronary angioplasty, *STEMI* ST-elevation myocardial infarction

[a]Variables that are statistically different between the two groups (p value ≤ 0.05)

[b]Includes a maximum of five readings taken within 72 h of STEMI diagnosis

Table 2 Treatment characteristics, process-of-care timings, and clinical outcomes among patients with STEMI

	Chest pain ($n=4064$, 87.1%)	No chest pain ($n=603$, 12.9%)	p value
Medications within 24 h, n (%)[a]			
Aspirin[b]	3921 (99.9)	483 (98.2)	< 0.001
Antiplatelet[b]	3986 (99.6)	458 (96.4)	< 0.001
Beta-blockers	2423 (96.3)	205 (94.0)	0.103
Reperfusion, n (%)			
Primary PCI[b]	3073 (75.6)	163 (27.0)	< 0.001
Urgent CABG	4 (0.1)	1 (0.2)	0.499
Process-of-care-timings in minutes[a]			
Symptom-to-door time, median (range)[b]	148 (0–10,556)	102 (10–7602)	< 0.001
Door-to-balloon time, median (range)[b]	63 (9–1641)	83 (29–1559)	< 0.001
Symptom-to-balloon, median (range)	204 (43–4643)	225 (78–1991)	0.806
Door-to-balloon time ≤ 60 min, n (%)[b]	1378 (44.8)	36 (22.1)	< 0.001
Door-to-balloon time ≤ 90 min, n (%)[b]	2448 (79.7)	98 (60.1)	< 0.001
Inpatient events, n (%)[a]			
Complete heart block[b]	108 (2.7)	28 (4.6)	0.006
Arrhythmia[b]	840 (20.7)	148 (24.5)	0.025
Acute renal failure[b]	151 (3.7)	81 (13.4)	< 0.001
Stroke	38 (0.9)	8 (1.3)	0.356
LVSD[b]	2367 (61.7)	337 (73.7)	< 0.001
28-day mortality, n (%)[b]	180 (4.4)	188 (31.2)	< 0.001
Cause of death, n (%)			0.323
AMI	124 (68.9)	121 (64.4)	
Non-AMI	53 (29.4)	66 (35.1)	
Unknown	3 (1.7)	1 (0.5)	

AMI acute myocardial infarction, *CABG* coronary artery bypass grafting, *LVSD* left ventricular systolic dysfunction, *PCI* percutaneous coronary intervention, *STEMI* ST-elevation myocardial infarction

[a]Patients with contraindications or whom the variable was not applicable to were excluded from the calculation of percentages

[b]Variables that are statistically different between the two groups (p value ≤ 0.05)

(13.4% vs. 3.7%, $p<0.001$), and left ventricular systolic dysfunction (73.7% vs. 61.7%, $p<0.001$). At 28 days following STEMI presentation at the ED, patients who did not have chest pain experienced seven times as much mortality (31.2% vs. 4.4%, $p<0.001$).

Independent predictors of a non-chest pain STEMI presentation

Table 3 displays variables predictive of a non-chest pain STEMI presentation. Adjusted positive predictors include an older age (adjusted odds ratio [aOR] = 1.05, 95% confidence interval [CI] 1.04–1.07), history of diabetes mellitus (aOR = 1.76, 95% CI 1.40–2.19), worse renal function (aOR = 1.01, 95% CI 1.00–1.02), and higher Killip scores (class 2 aOR = 1.53, 95% CI 1.08–2.16; class 3 aOR = 2.41, 95% CI 1.69–3.43; class 4 aOR = 2.50, 95% CI 1.74–3.59). Protective predictors included a higher body mass index (BMI) (aOR = 0.93, 95% CI 0.91–0.96), presence of dyslipidemia (aOR = 0.73, 95% CI 0.58–0.91), and increased hemoglobin (aOR = 0.91, 95% CI 0.86–0.96).

Independent predictors of 28-day mortality

Table 4 displays the variables predictive of 28-day mortality. The absence of chest pain was three times as likely to lead to mortality (aOR = 3.46, 95% CI 2.64–4.52). These patients were also older (aOR = 1.09, 95% CI 1.08–1.10), with worse renal function (aOR = 1.03, 95% CI 1.03–1.04), and with higher Killip scores (class 2 aOR = 1.24, 95% CI 0.83–1.86; class 4 aOR = 7.62, 95% CI 5.32–10.91). Among patients who underwent percutaneous coronary intervention, the absence of chest pain (aOR = 2.37, 95% CI 1.59–3.53) was an independent positive predictor of having a door-to-balloon time beyond 60 min (Supplementary Table 1).

Table 3 Independent predictors of a non-chest pain STEMI presentation among patients with STEMI

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age	1.08 (1.08–1.09)	1.05 (1.04–1.07)
Gender		
Male	1.00 (reference)	–
Female	3.46 (2.88–4.16)	–
Race		
Chinese	1.00 (reference)	–
Malay	0.72 (0.58–0.91)	–
Indian	0.51 (0.38–0.69)	–
Others	0.78 (0.37–1.64)	–
BMI	0.87 (0.84–0.89)	0.93 (0.91–0.96)
Smoking status		
Current	1.00 (reference)	–
Ex-smoker	2.31 (1.75–3.06)	–
Never	3.20 (2.60–3.94)	–
Past medical history		
Hypertension	1.85 (1.54–2.23)	–
Diabetes mellitus	1.63 (1.37–1.93)	1.76 (1.40–2.19)
Dyslipidemia	0.73 (0.62–0.87)	0.73 (0.58–0.91)
AMI/CABG/PCI	1.54 (1.22–1.93)	–
ECG diagnosis		
Anterior	1.27 (1.06–1.50)	–
Posterior	0.67 (0.50–0.90)	–
Inferior	0.70 (0.59–0.84)	–
Lateral	1.21 (1.02–1.44)	–
LBBB	5.95 (2.15–16.48)	–
Right ventricular	0.82 (0.55–1.23)	–
Creatinine	1.04 (1.03–1.05)	1.01 (1.00–1.02)
Hemoglobin	0.69 (0.67–0.72)	0.91 (0.86–0.96)
Killip score		
Class 1	1.00 (reference)	1.00 (reference)
Class 2	2.57 (1.95–3.38)	1.53 (1.08–2.16)
Class 3	3.81 (2.84–5.12)	2.41 (1.69–3.43)
Class 4	3.45 (2.59–4.60)	2.50 (1.74–3.59)

AMI acute myocardial infarction, *BMI* body mass index, *CABG* coronary artery bypass grafting, *CI* confidence interval, *ECG* electrocardiogram, *LBBB* left bundle branch block, *OR* odds ratio, *PCI* percutaneous coronary intervention, *STEMI* ST-elevation myocardial infarction

Table 4 Independent predictors of 28-day mortality among patients with STEMI

	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
No chest pain	9.77 (7.78–12.28)	3.46 (2.64–4.52)
Age	1.11 (1.10–1.12)	1.09 (1.08–1.10)
Gender		
Male	1.00 (reference)	–
Female	4.02 (3.22–5.01)	–
Race		
Chinese	1.00 (reference)	–
Malay	0.88 (0.67–1.15)	–
Indian	0.42 (0.28–0.64)	–
Others	0.48 (0.15–1.53)	–
BMI	0.86 (0.83–0.89)	–
Smoking status		
Current	1.00 (reference)	–
Ex-smoker	3.81 (2.66–5.47)	–
Never	4.22 (3.15–5.66)	–
Past medical history		
Hypertension	1.80 (1.43–2.27)	–
Diabetes mellitus	1.30 (1.05–1.61)	–
Dyslipidemia	0.59 (0.48–0.73)	–
AMI/CABG/PCI	1.46 (1.10–1.93)	–
ECG diagnosis		
Anterior	1.19 (0.96–1.48)	0.69 (0.43–1.10)
Posterior	0.72 (0.50–1.04)	–
Inferior	0.69 (0.56–0.87)	0.63 (0.39–1.02)
Lateral	1.24 (1.00–1.54)	–
LBBB	5.91 (2.01–17.38)	–
Right ventricular	0.56 (0.31–1.01)	0.39 (0.19–0.80)
Creatinine	1.05 (1.04–1.06)	1.03 (1.03–1.04)
Hemoglobin	0.67 (0.64–0.70)	–
Killip score		
Class 1	1.00 (reference)	1.00 (reference)
Class 2	2.64 (1.87–3.72)	1.24 (0.83–1.86)
Class 3	2.75 (1.86–4.07)	0.89 (0.57–1.41)
Class 4	8.53 (6.37–11.42)	7.62 (5.32–10.91)

AMI acute myocardial infarction, *BMI* body mass index, *CABG* coronary artery bypass grafting, *CI* confidence interval, *ECG* electrocardiogram, *LBBB* left bundle branch block, *OR* odds ratio, *PCI* percutaneous coronary intervention, *STEMI* ST-elevation myocardial infarction

Discussion

In this study, we utilised a national AMI registry to characterise STEMI patients who presented without chest pain. Patients who had a non-chest pain STEMI presentation were more likely to be older and with diabetes mellitus, and less likely to have an increased BMI or dyslipidemia. Severity of heart failure on presentation as classified by the Killip score was also increased. These patients were found to receive delayed and reduced rates of reperfusion therapy, and experienced poorer outcomes.

The prevalence of non-chest pain STEMI presentations in our population (12.9%) was on the lower end of the spectrum as compared to previously reported prevalences of between 8.4 and 33% [4, 6–8, 22]. This disparity could have arisen from population differences in ethnicity, comorbidities, and health-seeking behaviour, which might in turn affect STEMI

presentation. Differences may also have arisen from variability in study definitions and methodology.

When other demographic and clinical variables were controlled for, advanced age, diabetes mellitus as a comorbidity, raised serum creatinine, and an increased Killip score were found to be independent positive predictors of a non-chest pain STEMI presentation. The contribution of advanced age and diabetes mellitus toward a non-chest pain presentation is well documented in the literature [23], though its pathophysiology has not been well elucidated. Possible causes of a blunted pain perception include autonomic neuropathy, defective or inadequate stimulation of cardiac receptors, abnormalities in neuronal conduction, and neuropsychiatric factors [24–26]. With the prevalence of diabetes in Singapore projected to increase rapidly over the next few decades [27], STEMI diagnosis in the diabetic population would be made more challenging and would require a higher index of suspicion. The Killip score [28] was utilised in the ED to classify severity of presentation, and for prognostication. In our study, patients with more florid clinical signs of heart failure were more likely to have a non-chest pain STEMI presentation.

Independent negative predictors of a non-chest pain STEMI presentation were increased BMI, dyslipidemia as a comorbidity, and raised serum hemoglobin. The presence of increased BMI and dyslipidemia as negative predictors is intriguing, as these are conditions typically associated with a metabolic syndrome and neuropathy [24, 25] which may predispose instead to a non-chest pain presentation. There exists however the entity of an obesity paradox, which postulates that obesity, up to a certain point, may counterintuitively be protective against cardiovascular disease [29, 30]. In a study of 19,499 elderly patients with STEMI, individuals of BMI 30.0–34.9 were found to experience the least mortality as compared to individuals with lower and higher BMIs [31]. This association between BMI and mortality has been corroborated by other studies [32]. Other authors have hypothesized that this phenomenon may instead be a "lean paradox", where normal or underweight individuals experience poorer outcomes due to a catabolic state and loss of lean mass [33]. As such, further detailed analysis on our data set would be required to better understand the relationship between BMI, dyslipidemia, and mortality in our population.

Although not found to be statistically significant on multivariable analysis, several variables that were associated with an increased likelihood for a non-chest pain STEMI were female gender, Chinese race, and STEMI location. The predisposition of females toward a non-chest pain STEMI presentation has been previously reported, with contributory factors ranging from an under-appreciation of cardiac symptoms by women [34], an increased likelihood of additional symptoms which delay diagnosis [34], and an often mistaken belief by physicians that AMIs are not common amongst women [24]. Differences in STEMI location on ECG diagnosis were also noted between groups, with anterior STEMIs, lateral STEMIs, and left bundle branch blocks occurring more frequently in patients who presented without chest pain. Although not conclusively associated, several studies have reported different symptomatic presentations as influenced by the location of infarction [35, 36]. Interestingly, rates of EMS utilization were not significantly different between STEMI patients who presented with or without chest pain.

There are several strengths of our study. To the best of our knowledge, the issue of non-chest pain presentation of STEMI has not been studied in a national database. We do acknowledge several limitations. The poorer outcomes experienced by a non-chest pain STEMI presentation could have been influenced by delayed diagnosis and treatment. The SMIR, however, does not collect other process-of-care timings such as time taken from presentation to physician consult, or time taken from presentation to ECG diagnosis, that might better explain the reasons for treatment delay. These specific findings may need to be explored in further studies. Results may have been influenced by survivor bias, as patients who progressed to cardiac arrests were excluded from analysis. This may not be relevant, however, as patients who had a cardiac arrest would be recommended to have emergency PCI and have different process-of-care timings. Our study utilized data from 2010 to 2012 which represented a time lag of several years. This was due to limitations to data access, and further studies are thus needed to examine trends in non-chest pain STEMI presentations as they evolve over the years. Although mandatory notification of STEMI cases occurring in private hospitals was enacted only from 2012 onwards, we believe the non-mandatory contribution of data from private hospitals to have a small effect on the validity of the study. Public sector healthcare encompasses an overwhelming majority of all hospital care provided in Singapore, with public cases comprising nearly 98% of all cases in the SMIR [17].

A practical application from this study could be to conduct routine ECG readings for patients who have a high-risk profile for a non-chest pain STEMI presentation. For instance, all elderly female diabetics, with symptoms of dyspnea, diaphoresis, epigastric pain, or syncope. Doctors and nurses can be trained to better identify high-risk patients, and have a lower threshold for ordering an ECG should they suspect a non-chest pain STEMI presentation. Public education should be extended to the population-at-risk to educate them on non-chest pain presentations of STEMI, with counselling to seek prompt medical assistance.

Conclusion

Patients who presented with a non-chest pain STEMI had a distinct clinical profile, were often misdiagnosed, undertreated, and experienced poorer outcomes. Routine triage ECG could be considered for patients with high-risk factors and non-classical symptoms.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval This study was approved by SingHealth Centralised Institutional Review Board (CIRB Ref 2014/130/C) with a waiver of patient consent.

Statement of human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institution and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required. This article does not contain any studies with animals performed by any of the authors.

Informed consent For this type of study formal consent is not required.

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