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Cardiac Shock in Patients Hospitalized for Acute Myocardial Infarction

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ABSTRACT

Introduction: There is a paucity of data on in-hospital outcomes and mortality in individuals with myocardial infarction (MI) complicated by cardiogenic shock (CS). However, this complication greatly affects prognosis amongst other factors and is a fairly common concern. We aim to add to the existing body of knowledge in this regard. ***Methods and Results:*** Patients with MI admitted from January 1, 2005, to December 31, 2014, were identified from the US National Inpatient Sample. We reported the crude and adjusted trends of in-hospital mortality among the population and selected subgroups. Among 73,573,571 hospitalizations spanning from January 1, 2005, to December 31, 2014, 1,208,029 (1.65%) were attributed to MI. Of these, the number of hospitalized individuals admitted primarily for myocardial infarction with a secondary diagnosis of CS (MICS) was 60,661 (5.02%), 62% (37,885) of which were men. The prevalence by racial ethnicity was 76.13% (39,282) whites, 7.51% (3873) blacks, and (4239) 8.22% Asians. The mean age of all affected with MICS was 68.6 years (SD=13.2). The mortality outcome of the 60661 affected was 21283, i.e., 35.10% mortality. There has been a steady increase in hospitalizations in individuals with myocardial infarction and a secondary diagnosis of cardiogenic shock from 68 per 100 000 hospitalizations in 2005 to 103 per 100 000 hospitalizations in 2014 (p =0.001), it showed 9% vs. 12.2% increase (p =0.001). Of the people that died from MICS, 76.30% (13,754) were white, and Asians and blacks were 8.38% (1,510) and 7.54% (1,359). However, there was no statistical significance in racial differences as p =0.33. Mortality across the various hospital regions showed no statistical significance, p =0.88. However, the mortality among patients with MICS in the in-hospital setting decreased (from 40.80% (2226/5456) in 2005 to 33.70% (2456/7288) in 2014; p =0.001). The mean length of stay (LOS) trend decreased from 9.14 days (SD=10.6) in 2010 to 8.88 days (SD=10.6) in 2013 (p =0.001). There was, however, an upsurge in total hospital charges (CRG) from $147,727 (SD=153,847) in 2010 to $172,357 (SD=201,168) in 2013 (p =0.001). Weekend or weekday admission showed no significant difference in mortality outcome, 73.01% (44,263) vs. 26.99% (16,363) (p =0.18). The adjusted rate for mortality by month revealed that there was a significant increase in in-hospital mortality in December and January (p =0.005).

There was a significant difference among patients with congestive cardiac failure (CCF), p =0.001, but type 2 diabetes (T2DM) did not significantly affect the mortality outcomes of these patients. ***Conclusions:*** Hospitalizations attributed to MICS rose significantly from January 2005 to December 2014. Our study delineated a decline in MICS in-hospital mortality during this period. Furthermore, a general increase in mortality during December and January was observed in the studied population.

Keywords: cardiac shock; acute myocardial infarction; patients hospitalized

INTRODUCTION

Acute myocardial infarction (AMI) results from unstable ischemia, leading to myocardial necrosis [1]. It is a typical cardiac emergency with potential morbidity and mortality [2]. AMI causes more than 2.4 million deaths in the United States and more than 4 million deaths annually in Europe and northern Asia [3]. It also causes one-third of the deaths in developed countries annually [4]. Although there has been an increase in evidence-based therapies and lifestyle changes, AMI continues to affect more than 7 million individuals worldwide each year [3, 5].

Cardiogenic shock (CS) is a feared complication of AMI and is a leading cause of death after an acute myocardial infarction [6, 7]. CS occurs due to ventricular failure after AMI, accounting for 80% of cases [8]. CS occurs due to a reduction in myocardial contractility, leading to diminished cardiac output, hypotension, systemic vasoconstriction, and ischemia [9]. The incidence of CS has increased over the last decade, and improved diagnosis and treatment of AMI and better access to health care are likely contributory factors [10].

The mortality rates among patients with CS are exceedingly high in the absence of aggressive therapy [7]. A study in Pakistan between January 2014 and December 2017 evaluated the frequency of in-hospital mortality in patients who develop CS after acute myocardial infarction [7]. Furthermore, in a prospective study by Otaal et al., while assessing cohorts with worse outcomes of hemodynamic instability following complete occlusion of the left anterior descending artery, a lower left ventricular ejection fraction, diabetes, elevated troponin T level, and individuals with poor cardiovascular collateral arteries have worse outcomes in comparison to matched counterparts [11]. These populations were found to be more likely to develop CS following an event of acute myocardial infarction [11].

They found out that there was a 44.7 % rate of in-hospital mortality in patients that developed cardiogenic shock after an AMI [7]. They also found some risk factors associated with mortality were hypertension, diabetes, age, and body mass index (BMI) [7]. They recommended that rapid diagnosis of CS, understanding, evaluating, managing the risk factors, and early revascularization would help achieve a good outcome and reduce in-hospital mortality [7]. In addition, a recent study demonstrated that global longitudinal and territorial strain echocardiography estimation could help in prompt diagnosis, identification, and therefore better prognosis for patients who develop cardiogenic shock in individuals with anterior wall myocardial infarction outside the desired intervention window period [12]. Our study aims to assess the trends in in-hospital mortality in patients with AMI and CS (MICS).

MATERIALS & METHODS

Study Data

We derived this study from the National Inpatient Sample (NIS) data from January 1, 2005, to December 31, 2014, to evaluate emerging trends within the last decade with the improvement of interventional medical technologies and techniques. This dataset is part of the Healthcare Cost and Utilization Project (HCUPS) databases sponsored by the Agency for Healthcare Research and Quality [13]. This dataset has been deidentified and made publicly available; hence there is no requirement for consent from the Institutional Review Board.

Study Population

Adult patients (≥18 years) admitted with all categories of Myocardial Infarction (MI) i.e DX1 only, from January 1, 2005, to December 31, 2014, were identified in the NIS using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 41000, 41001, 41002, 41010, 41021, 41022, 41030, 41031, 41032, 41040, 41051, 41062, 41070, 41071, 41072, 41080, 41081, 41082, 41081, 41090, 41091, and 41092 to all represent MI. Individuals with MI as the primary and secondary diagnosis of cardiogenic shock (CS) were identified using the ICD-9 code 78551, i.e., DX2 to DX30. The ICD-9-CM codes for MI and CS used in the current study have been validated [10]. An illustration of the study population is represented in figure 1 below.

Exclusion criteria

(1) Patients with missing records, i.e., mortality, age, or sex data, and (2) patients aged <18 years. We reported the mean age, trends of in-hospital mortality, length of stay, cost of hospitalization, and racial/ethnic prevalence in the following populations: (1) among all patients who received the diagnosis of MI during their hospitalization with a secondary diagnosis of CS (MICS). The cohort of MICS was identified by selecting patients with a primary diagnosis of MI, i.e., DX1, and then identifying the population with a DX1 of MI and a secondary diagnosis of CS, i.e., DX2-DX30. Additionally, demographical representation with regional variations, sex, and the race was applied to the analysis.

Study Outcomes

The study's primary outcome was the trend of in-hospital mortality. In contrast, the secondary outcome was the mean length of stay, variations in outcome between weekend versus weekday admission outcomes, variation of months of the year admission outcomes, variation in hospital region outcomes of MICS, and total hospital charges during the study period.

Statistical Analysis

The variables in the dataset were weighted as national estimates. This was achieved by incorporating the survey analysis method into HOSP_NIS and accounting for the various strata within the NIS design as recommended in the Agency for Healthcare Research and Quality methods series [13]. A P value of <0.05 was adopted to be statistically significant. All statistical analyses were performed using the Statistical Analysis System Software (SAS) version 9.4.

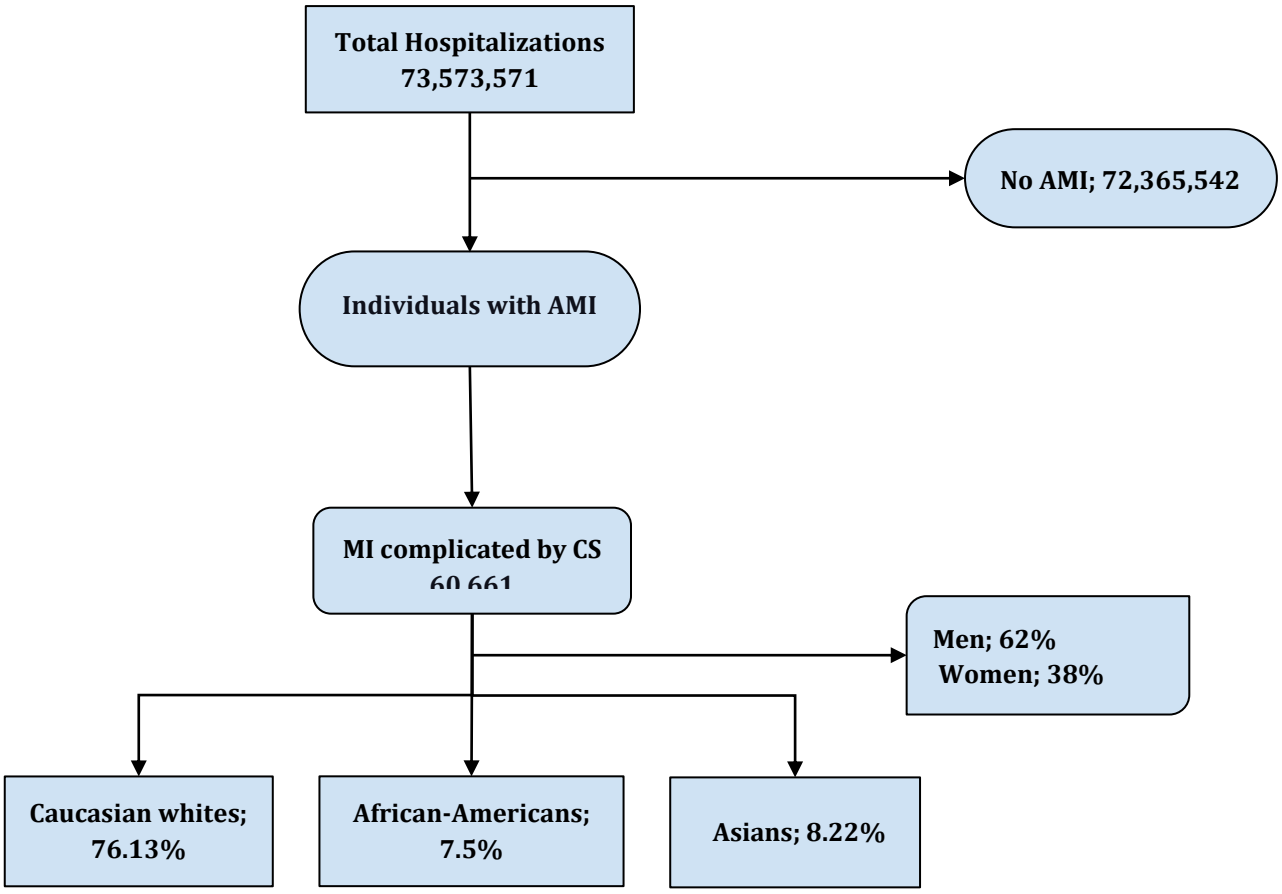

FIGURE 1: Flow Chart Illustration.
AMI= Acute Myocardial Infarction, MI= Myocardial Infarction, CS= Cardiogenic Shock.

RESULTS

Among 73,573,571 hospitalizations from January 1, 2005, to December 30, 2014, 1,208,029 (1.65%) were attributed to MI, while 60,661 (5.02%) of those who had MI had secondary CS (MICS), 62% of which were men. The prevalence by racial ethnicity was 76.13% (39,282) whites, 7.51% (3873) blacks, and 8.22% (4239) Asians. The mean age of all affected with MICS was 68.6 years, with a Standard Deviation of 13.2. However, as P =0.33, racial differences had no statistical significance.

From figure 2 below, our study highlighted a point prevalence increase in hospitalizations for MICS from 68 per 100 000 hospitalizations in 2005 to 103 per 100 000 in 2014 (p =0.001). A reduction in in-hospital mortality accompanied this trend, from 40.80% (2226/5456) in 2005 to 33.70% (2456/7288) in 2014 (p =0.001). Furthermore, there was a significant increase in in-hospital mortality in December and January (P =0.005). Mortality across the various hospital regions showed no statistical significance (p =0.88).

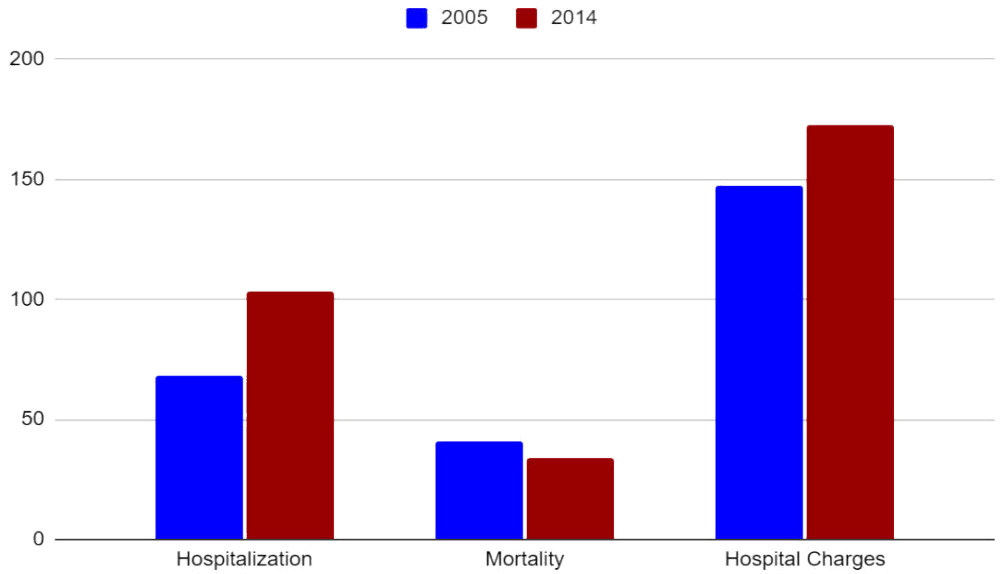

FIGURE 2: Comparative difference in the prevalence of hospitalization, mortality, and hospital charges
P< 0.05 is taken to be significant for the interpretation of the presented data

The mortality outcome of the 60661 affected was 21283, i.e., 35.10%, as seen in figure 3. With respect to the mean length of stay (LOS), there was a decrease from 9.14 days (SD=10.6) in 2010 to 8.88 days (SD=10.6) in 2013 (Ptrend 0.001). There was, however, an upsurge in total hospital charges (CRG) from $147,727 (SD=153,847) in 2010 to $172,357 (SD=201,168) in 2013 (P =0.001). Due to missing data, we could not include the complete 2005-2014 years' trend in the cost of hospitalization.

Weekend or weekday admission showed no significant difference in mortality outcome, 73.01% (44,263) vs. 26.99% (16,363) (p =0.17). There was a modest increase in in-hospital mortality in December (1842/5255) and January (1846/5022), mean (1844/5138) (35.9%) versus the mean of other months (1625/4665) (34.8%) (P =0.005). There was a significant difference among patients with congestive cardiac failure (CCF) (p =0.001), but type 2 diabetes (T2DM) did not significantly affect the mortality outcomes in these patients.

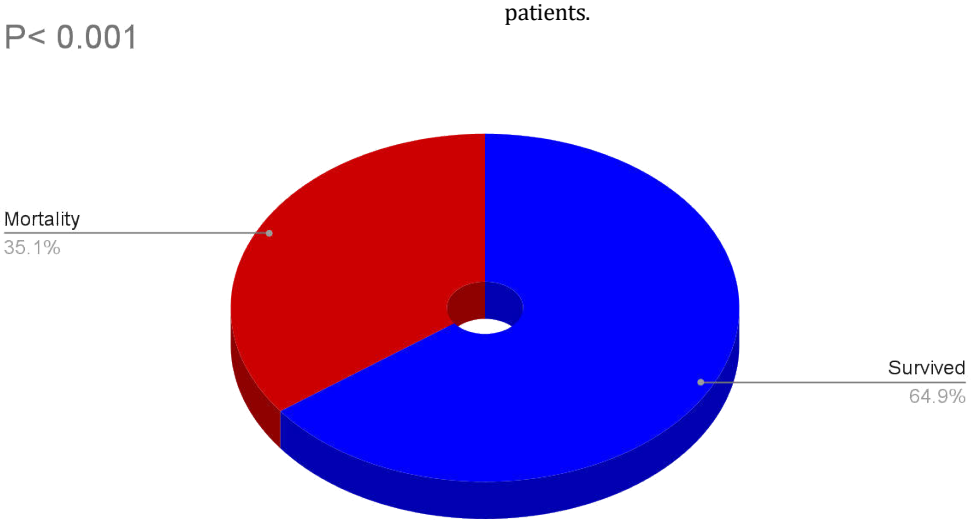

FIGURE 3: Percentage of survivors of MICS during hospitalization
P< 0.05 is taken to be significant for this study

TABLE 1: Percentage of Individuals with MICS; Survived vs. Died.
%=percentage

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SURVIVED	3176	2919	3332	3033	3157	2941	2992	2910	2836	3111	3149	3413
%	63.24	62.44	66.01	64.90	65.09	65.63	66.19	65.06	65.53	65.19	65.13	64.95
DIED	1846	1756	1716	1640	1693	1540	1528	1563	1492	1661	1686	1842
%	36.76	37.56	33.99	35.10	34.91	34.37	33.81	34.94	34.47	34.81	34.87	35.05
TOTAL	5022	4675	5048	4673	4850	4481	4520	4473	4328	4772	4835	5255

DISCUSSION

Myocardial infarction (MI) is a prominent complication of cardiovascular disease worldwide. It is an injury to the myocardium due to absent or decreased oxygen supply to any areas of the myocardium, most commonly in the distribution of the left descending artery (LAD) [4,5]. Various events can complicate MI management, hospital course, and outcomes, including ventricular tachyarrhythmias, papillary muscle rupture, interventricular septum rupture, postinfarction pericarditis, Dressler's pericarditis, and cardiogenic shock [2]. Anatomic dysfunction resulting in critical end-organ hypoperfusion is a simple way to define cardiogenic shock (CS). It contributes significantly to the cause of death in patients hospitalized for acute myocardial infarction [14], and MICS-related hospitalizations can dramatically increase the in-hospital mortality rate. While our study revealed a steady rise in MICS hospitalizations from 2005 to 2014, in-hospital mortality significantly decreased from 40.8% to 33.7% (p =0.001). December and January had the highest mortality rates compared to other months. There was a reduction in the length of hospital stay from 9.16 days in 2010 to 8.88 days in 2013 (p =0.001), and total hospital charges increased by 16.7%.

Cardiogenic shock occurs in up to 10% of patients immediately following acute myocardial infarction and is associated with mortality rates of nearly 40% at 30 days and 50% at one year [14]. Our study only detected a 5.02% prevalence, probably due to missing data or under-coding from hospital administrators. Of note, this is real-world data. Still, one must acknowledge that the mortality rates are much lower in the various RCTs comprising cardiogenic shock patients, generally around 20-30% [15]. The steady rise in MICS hospitalizations from 2005 to 2014 was consistent with a study in Switzerland where the authors reported an increase in CS admission among patients with MICS between 1997 and 2017 by more than double from 2.5% to 4.6% [10,16, 17, 18]. Also, in a retrospective report from the Mayo Clinic cardiac intensive care unit, which included >12 000 patients, an increase in CS incidence by almost 4-fold from 5.7% in 2007 to 2009 to 19.4% from 2016 to 2018 was reported [19]. It is worthy of note that despite the reduction in the mean length of stay from 9.6 to 8.8 (p =0.05), the hospital charges went up substantially throughout the study period. Perhaps this is due to recent, more complex investigations, treatment modalities, and medications [19]. Another study found that there has been a skyrocketing in hospital bills over the past decade due to complex interventional treatments, overtesting, and expensive medications on the market (13, 20). Perhaps a more explicit guideline on the approach to a patient with MICS, including investigations and treatment, will help limit overtesting and consequent exorbitant hospital charges.

The decrease in in-hospital mortality during the study period from 40.8% in 2005 to 33.7% in 2014 is concordant with other studies [20], which may be attributable to the significant advances in healthcare in the US [20]. The initial goals of the management of CS are to achieve euvolemia and hemodynamic stabilization and prevent the development of multiorgan system dysfunction [18]. Several measures have been employed in managing emergent CS, including the Intraaortic balloon pump and continuous monitoring using Pulmonary artery catheterization [21, 22]. The increased availability and utilization of mechanical revascularization, especially when implemented early, also the introduction of improved 2nd generation drug-eluting stents aided in directly reducing long-term target lesion revascularization rates. All these have been touted as probable reasons for the reduction in in-hospital mortality [23]. In the SHOCK trial, there was no reduction in 30-day mortality versus medical therapy alone after revascularization. However, the reduction in mortality was seen after six months and then at follow-up ten years later [17, 24]. Despite an increase in survival rate in the in-hospital setting over the study duration, there is a significant 20% risk of readmission within 30-days of discharge, most commonly due to congestive heart failure and new onset MI [15].

The relatively higher in-hospital MICS mortality observed in December and January could be due to several factors. December and January are the coldest months in the United States, recording the lowest temperatures during the year [24-25]. Acute myocardial infarction (AMI) occurs more frequently in cold weather [25-26]. There is well-studied literature on the variation of cardiovascular disease with the season, and the highest incidence occurs globally during winter. One of the proposed pathogenesis is that the blood pools centrally in the body with subsequent activation of the RAAS, leading to hemoconcentration and increasing the risk for thrombosis [25,27,28]. Individuals with AMI will likely present late to the hospital in winter due to longer EMS response times due to bad weather and increased call-out volumes [29]. AMI was first noted to occur more frequently in the winter months in 1930. It was described by Master et al. Although one Hungarian study found the peak prevalence during the spring season [30], several other studies [31-34], including a Thomas Fischer et al., led Danish population study, found significant overall increased cardiovascular mortality during the winter season. The consistency was seen across all age groups but not sex. The male sex reportedly experienced increased cardiovascular morbidity and mortality during the winter season, but this was unchanged for females [34].

Further study is needed to ascertain why similar trends are absent in the "hot" months, as similar factors may also be present. According to Hashmi, in 2018, there was an increase in in-hospital mortality in patients with cardiogenic shock after acute myocardial infarction due to underlying risk factors and type of intervention. Rapid diagnosis of cardiogenic shock after an acute MI, evaluation of underlying risk factors (such as hypertension and diabetes), and early revascularization reduce in-hospital mortality [34]. Our study's strength is from the cumulative dataset of over a decade of observational data, the inclusiveness of the majority of hospitalizations into the Nationwide Wide Inpatient Sample gives an idea of hospitalization outcomes, the effectiveness of therapy, and guidelines over the past decade.

LIMITATIONS

The NIS data is limited because it is impossible to ascertain if a diagnosis was made during the most recent hospitalization or if a patient carries a history of such a diagnosis. The NIS entry corresponds to a single hospitalization. One patient can be erroneously assigned with multiple entries if hospitalized more than once within the study period. Except for CCF and T2DM, other comorbidities were not considered during this data analysis. The NIS is an administrative data used by hospitals for billing; hence it may be prone to overbilling, underbilling, and other human errors.

CONCLUSIONS

Cardiogenic shock complicates the care and prognosis of individuals admitted to the hospital following myocardial infarction. A high index of suspicion, immediate diagnosis, and management are required to improve prognosis. The data shows a high mortality rate; hence active steps should be put in place to prevent the onset of cardiogenic shock in individuals with MI. This study elaborated on the outcomes of cases in hospitalized adult patients. A steady increase in hospitalizations was attributed to MICS and a decrease in in-hospital mortality during the study periods. The cause of outcome variation during December and January calls for further study, perhaps it will be worthy of note to raise awareness and educate the public about necessary steps to take during these months to overcome the barriers to obtaining timely interventions.

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ABBREVIATIONS; MI, CS, MICS, AMI, NIS
MI; Myocardial Infarction
CS; Cardiogenic shock
MICS; Myocardial Infarction complicated with Cardiac shock
AMI; Acute Myocardial Infarction
NIS; Nationwide Inpatient Sample