Obesity Impacts Mortality and Rate of Revascularizations Among Patients With Acute Myocardial Infarction: An Analysis of the National Inpatient Sample

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Abstract

Background
Obesity is now a recognized chronic comorbid condition which is highly prevalent in the United States. Obesity poses several health risks, affecting multiple organ systems. The cardiovascular system is particularly affected by obesity including its role in atherosclerotic disease and hence myocardial infarction (MI) from atheromatous plaque events. However, multiple population-based studies have shown mixed outcomes in obese patients who have acute MI. This study aimed to determine if obesity paradoxically improved outcomes in patients with acute myocardial infarction (AMI) as well as compare outcomes of mild to moderately obese patients and morbidly obese patients to non-obese patients.

Materials and methods
Data was obtained from the Nationwide Inpatient Sample (NIS) for 2016 and 2017. The study included adult patients with a principal discharge diagnosis of AMI. This group was divided into ST segment elevation myocardial infarction (STEMI) and non-ST segment myocardial infarction (NSTEMI). Obese patients were subdivided into two groups: mild-moderate obesity and morbid obesity. Primary outcome compared inpatient mortality. Secondary outcomes included rate of percutaneous coronary intervention (PCI), coronary artery bypass grafting (CABG), composite revascularization, mean length of hospitalization, total hospital charges, and rates of complications.

Results
In patients with STEMI, mild to moderately obese patients had lower odds of mortality (aOR: 0.80, 95% CI: 0.715-0.906, p < 0.001) compared to non-obese patients. However, morbidly obese patients had higher odds of mortality (aOR: 1.26, 95% CI: 1.100-1.446, p < 0.001) compared to non-obese patients. Mild to moderately obese patients had higher odds of composite revascularization (aOR: 1.24, 95% CI: 1.158-1.334, p < 0.001), PCI (aOR: 1.08, 95% CI: 1.054-1.150, p = 0.014), and CABG (aOR: 1.46, 95% CI: 1.313-1.626, p < 0.001).

Conclusion
The degree of obesity affects outcome of patients with AMI. Cardiovascular interventions during hospitalizations for AMI also varied with degree of obesity. This may have affected the outcome, especially among morbidly obese patients.

Introduction
Obesity is now a recognized chronic comorbid condition which is highly prevalent in the United States. It has a higher prevalence among the middle age female population [1, 2]. Obesity poses several health risks, affecting multiple organ systems [3, 4]. The cardiovascular system is particularly affected by obesity. The mechanism through which obesity affects the cardiovascular system includes adipokine dysregulation, inflammation, increased circulating free fatty acids, increased oxidative stress and adipose tissue hypoxia, ultimately contributing to atherosclerosis and the development of atheromatous plaques [5]. The development and subsequent disruption of atheromatous plaques results in atherothrombosis, which is the hallmark of acute myocardial infarction (AMI) [6]. Studies involving outcomes of AMI in obese population have yielded mixed results [7-11]. Improved outcomes have fueled concepts including metabolically healthy obesity and the obesity paradox relating to cardiovascular diseases. It is also suggested that this paradox may be due to unaccounted confounding factors yet to be objectively identified [12]. This study aimed to
determine if obesity paradoxically improved outcomes in patients with AMI as well as compare outcomes of mild to moderately obese patients and morbidly obese patients to non-obese patients.

**Materials And Methods**

**Design and data source**

This study was a retrospective cohort study involving adult patients (aged ≥ 18 years) hospitalized for AMI in the US between January 1, 2016 and December 31, 2017. Data was obtained from the Nationwide Inpatient Sample (NIS) database for 2016 and 2017. The NIS is a database of hospital inpatient stays derived from billing data submitted by hospitals to statewide data organizations across the US, covering more than 97% of the US population [13-16]. It approximates a 20% stratified sample of discharges from US community hospitals, excluding rehabilitation and long-term acute care hospitals [17,18]. This dataset is weighted to obtain national estimates [19,20]. Both the 2016 and 2017 database are coded using the International Classification of Diseases, Tenth Revision, Clinical Modification/Procedure Coding System (ICD-10-CM/PCS) [21,22].

**Study population**

The study included adult patients with a principal discharge diagnosis of AMI (n = 1,299,885). This group was divided into ST segment elevation myocardial infarction (STEMI: I21.0, I21.1, I21.2, I21.3) and non-ST segment myocardial infarction (NSTEMI: I21.4). A total of 349,900 hospitalizations were for STEMI, out of which 16.5% (n = 57,734) were obese and 83.5% (n = 292,166) were non-obese. A total of 949,985 hospitalization were for NSTEMI, out of which 19.8% (n = 188,097) were obese and 80.2% (n = 761,888) were non-obese (Figure 1). Patients were excluded if STEMI or NSTEMI was a secondary diagnosis or if they developed AMI following a procedure. The cohort of patients with AMI was further divided based on the presence of a secondary discharge diagnosis of obesity (E66.0, E66.1, E66.2, E66.8, E66.9, Z68.3, Z68.4). We combined both general codes for obesity as well as BMI specific codes to accurately capture obesity categories. Obese patients were subdivided into two groups: mild-moderate obesity and morbid obesity, using the above codes, correlating with a BMI of 30-39 and 40 and above, respectively. The ICD-10-CM/PCS codes used to obtain the cohort can be found in the Appendix.

**Outcome measures**

The primary outcome was comparing inpatient mortality among patients with AMI based on presence or absence of obesity. Secondary outcomes in this population included need for percutaneous coronary intervention (PCI) with drug eluting stent and bare metal stent placement, coronary artery bypass grafting (CABG), and composite revascularization (PCI and CABG). Other outcomes included rate of complications including need for electrical cardioversion/defibrillation and odds of having a secondary discharge diagnosis of acute kidney failure (AKI) and cardiogenic shock. We also compared mean length of hospitalization as well
as total hospital charges between both groups as measures of healthcare utilization cost.

**Statistical analysis**

Data was analyzed using Stata® (Statistics and Data) Version 16 software (StataCorp, Texas, USA). All analyses were conducted using the weighted samples for national estimates in adjunct with Healthcare Cost and Utilization Project regulations for using the NIS database. Co-morbidities were calculated as proportions of the cohort and Chi squared test was used to compare association between the non-obese and the obese subgroups. Multivariate regression analysis was done to adjust for possible confounders while calculating the primary and secondary outcomes. The patient and hospital characteristics as well as co-morbidities were obtained during literature review. A univariate screen was done to further confirm these factors. Variables with p < 0.2 in univariate screen were included in multivariable regression model. A p-value of 0.05 was set as the threshold for statistical significance in the multivariate regression analysis.

**Ethical considerations**

The NIS database does not contain patient identifiers. Since 2012, the NIS has also removed state level and hospital identifiers. This has enhanced patient protection and anonymity. This study was exempt from Institutional Review Board approval.

**Results**

**Characteristics of STEMI patients**

Data showed 349,900 hospitalizations were for STEMI during the study period. The prevalence of obesity among patients with STEMI was 16.5%.

Obese patients were significantly younger (59.2 vs 64.3 years, p < 0.001), with a higher proportion of females (34.4 vs 30.2%, p < 0.001). Compared to non-obese patients, obese patients had a higher proportion with comorbidities including hypertension (57.3 vs 50.7%, p < 0.001), diabetes (47.9 vs 28.0%, p < 0.001), smoking history (52.5 vs 51.4%, p < 0.054), congestive heart failure (25.7 vs 23.0%, p < 0.001) and chronic kidney disease (10.5 vs 8.5%, p < 0.001) (Table 1).

| Variable                  | STEMI N = 349,900 | NSTEMI N = 949,985 | p-value |
|---------------------------|-------------------|--------------------|---------|
| Obese, %                  | Non-obese, %      | Obese, %           | Non-obese, % | p-value |
| Percent                   | 16.5              | 83.5               | 19.8     | 80.2   |
| Mean Age, years           | 59.2              | 64.3               | <0.001   | 63.0   | 69.5   | <0.001   |
| Females                   | 34.4              | 30.2               | <0.001   | 42.8   | 40.1   | <0.001   |
| Racial distribution       |                   |                    | <0.001   |        |        |
| White                     | 73.1              | 72.0               | 70.2     | 70.5   |
| Black                     | 9.4               | 8.2                | 13.4     | 11.4   |
| Hispanic                  | 8.2               | 7.8                | 8.6      | 8.1    |
| Others                    | 9.3               | 12.0               | 7.8      | 10.0   |
| Insurance type            |                   |                    | <0.001   | <0.001 |
| Medicaid                  | 37.4              | 48.5               | 54.2     | 66.3   |
| Medicare                  | 12.8              | 10.6               | 11.3     | 8.7    |
| Private                   | 42.6              | 34.1               | 30.0     | 21.4   |
| Uninsured                 | 7.2               | 6.8                | 4.5      | 3.6    |
| Charlson Comorbidity Index score | <0.001 | <0.001 |
| 1                         | 25.7              | 34.7               | 20.5     | 21.6   |
| 2                         | 32.4              | 30.8               | 22.5     | 20.5   |
| ≥3                        | 41.9              | 34.5               | 57.0     | 55.9   |
| Median annual income expected for patient’s zip code, US$ |   |   |<0.001|<0.001|
|---|---|---|---|---|
| 1-43,999 | 26.6 | 26.5 | 32.7 | 31.3 |
| 44,000-55,999 | 28.2 | 27.5 | 28.1 | 27.4 |
| 56,000-73,999 | 25.0 | 23.9 | 23.4 | 23.0 |
| ≥74,000 | 18.2 | 20.1 | 15.8 | 18.3 |

**Comorbidities**

| Hypertension | 57.3 | 50.7 |<0.001 |47.6 | 45.8 |<0.001|
| Diabetess | 47.9 | 28.0 |<0.001 |60.2 | 39.1 |<0.001|
| Smoking history | 52.5 | 51.4 | 0.034 | 49.2 | 47.7 |<0.001|
| Atrial fibrillation/flutter | 14.1 | 14.4 | 0.372 | 20.6 | 22.1 |<0.001|
| CHF | 25.7 | 23.0 |<0.001 |39.6 | 37.2 |<0.001|
| CKD | 10.5 | 8.5 |<0.001 |23.8 | 21.6 |<0.001|
| Dialysis dependence | 1.2 | 1.1 | 0.643 | 3.5 | 4.0 |<0.001|
| Dyslipidemia | 72.4 | 61.3 |<0.001 |75.3 | 65.6 |<0.001|
| Chronic IHD | 87.1 | 84.2 |<0.001 |83.1 | 80.1 |<0.001|
| Old PCI | 1.4 | 1.5 | 0.874 | 1.7 | 1.8 | 0.148|
| Old CABG | 4.1 | 4.5 | 0.102 | 10.6 | 12.9 |<0.001|
| Pacemaker | 0.8 | 1.2 |<0.001 |2.5 | 4.0 |<0.001|
| Prior CVA | 1.1 | 1.3 | 0.112 | 2.3 | 2.7 |<0.001|
| Liver disease | 4.8 | 4.3 | 0.012 | 3.6 | 3.0 |<0.001|
| COPD | 12.2 | 11.7 | 0.103 | 21.6 | 20.2 |<0.001|
| Supplemental O₂ | 1.3 | 0.9 |<0.001 |3.7 | 2.8 |<0.001|
| Hypothyroidism | 9.0 | 8.4 | 0.045 | 13.3 | 13.1 | 0.171|
| Electrolyte disorders | 20.6 | 20.1 | 0.186 | 22.1 | 22.2 | 0.837|
| Anemia | 15.9 | 14.8 | 0.004 | 26.2 | 25.7 | 0.040|

**Hospital characteristics**

| Hospital region |   |<0.001|   |<0.001|
|---|---|---|---|---|
| Northeast | 15.8 | 17.1 | 16.0 | 18.6 |
| Midwest | 25.8 | 22.2 | 25.2 | 21.7 |
| South | 39.8 | 40.6 | 40.8 | 41.0 |
| West | 18.6 | 20.1 | 18.0 | 18.7 |
| Hospital bed size | 0.462 | 0.030|
| Small | 15.1 | 14.5 | 16.6 | 17.4 |
| Medium | 29.6 | 29.8 | 30.5 | 30.8 |
| Large | 55.3 | 55.7 | 52.9 | 51.8 |
| Urban location | 94.3 | 93.3 |<0.001 | 93.0 | 91.6 |<0.001|
| Teaching hospital | 68.8 | 67.6 | 0.035 | 68.0 | 65.6 |<0.001|
Primary outcome in STEMI patients: in-hospital mortality

The in-hospital mortality for patients with STEMI was 8.0% overall. Mild to moderately obese patients had lower odds of mortality (aOR: 0.80, 95% CI: 0.715–0.906, p < 0.001) compared to non-obese patients. However, morbidly obese patients had higher odds of mortality (aOR: 1.26, 95% CI: 1.100–1.446, p < 0.001) compared to non-obese patients (Tables 2, 3).

| Outcome                        | Mild-moderate, % | Nonobese, % | aOR (95% CI)          | p-value  |
|--------------------------------|-----------------|-------------|-----------------------|----------|
| **Primary outcome**            |                 |             |                       |          |
| In-hospital mortality          | 5.1             | 8.4         | 0.80 (0.715 – 0.906)  | <0.001*  |
| **Secondary outcomes**         |                 |             |                       |          |
| Mean Length of stay, days (95% CI) | 4.1 (3.9 - 4.2) | 4.0 (4.0 - 4.1) | 0.00 (-0.107 – 0.102) | 0.965    |
| Mean total hospital charges, US$ (95% CI) | 113000 (109300 – 116600) | 107600 (105400 – 109800) | 2200 (-800 – 5100) | 0.151    |
| PCI with DES                   | 69.9            | 65.1        | 1.12 (1.054 – 1.180)  | <0.001*  |
| PCI with BMS                   | 8.6             | 9.2         | 0.93 (0.851 – 1.023)  | 0.138    |
| PCI                            | 77.4            | 73.5        | 1.08 (1.016 – 1.150)  | 0.014*   |
| CABG                           | 7.6             | 4.7         | 1.46 (1.313 – 1.628)  | <0.001*  |
| Revascularization              | 83.9            | 77.7        | 1.24 (1.158 – 1.334)  | <0.001*  |
| AKI                            | 15.6            | 15.7        | 1.10 (1.013 – 1.193)  | 0.023*   |
| Electrical cardioversion/defibrillation | 4.6            | 4.0         | 1.18 (1.041 – 1.326)  | 0.009*   |
| Cardiogenic shock              | 11.5            | 13.3        | 0.91 (0.837 – 0.992)  | 0.032*   |

**TABLE 2: Clinical outcomes of STEMI in mild to moderately obese patients**

*: Statistically significant, AKI: Acute kidney failure, aOR: adjusted odds ratio, BMS: Bare metal stent, CABG: Coronary artery bypass grafting, CI: Confidence interval, DES: Drug eluting stent, PCI: Percutaneous coronary intervention, STEMI: ST segment elevation myocardial infarction.
### Clinical outcomes of STEMI in morbidly obese patients

| Outcome                              | Morbid obesity, % | Nonobese, % | aOR (95% CI) | p-value |
|--------------------------------------|-------------------|-------------|--------------|---------|
| **Primary outcome**                  |                   |             |              |         |
| In-hospital mortality                | 7.8               | 8.4         | 1.26 (1.100 – 1.446) | 0.001* |
| **Secondary outcomes**               |                   |             |              |         |
| Mean Length of stay, days (95% CI)   | 4.7 (4.5 – 4.9)   | 4.0 (4.0 – 4.1) | 0.34 (0.170 – 0.516) | <0.001* |
| Mean total hospital charges, US$ (95% CI) | 120500 (115900 – 125200) | 107600 (105400 – 109800) | 7900 (3900 – 12000) | <0.001* |
| PCI with DES                         | 63.5              | 65.1        | 0.91 (0.841 – 0.973) | 0.007* |
| PCI with BMS                         | 10.0              | 9.2         | 1.11 (0.994 – 1.235) | 0.063   |
| PCI                                  | 72.5              | 73.5        | 0.92 (0.846 – 0.991) | 0.030*  |
| CABG                                 | 6.8               | 4.7         | 1.35 (1.170 – 1.559) | <0.001* |
| Revascularization                    | 78.8              | 77.7        | 0.99 (0.911 – 1.086) | 0.905   |
| AKI                                  | 21.0              | 15.7        | 1.47 (1.333 – 1.610) | <0.001* |
| Electrical cardioversion/defibrillation | 5.2               | 4.0         | 1.31 (1.128 – 1.528) | <0.001* |
| Cardiogenic shock                    | 13.6              | 13.3        | 1.05 (0.944 – 1.160) | 0.383   |

**Secondary outcomes in STEMI patients**

Mild to moderately obese patients had higher odds of composite revascularization (aOR: 1.24, 95% CI: 1.158–1.334, p < 0.001), PCI (aOR: 1.08, 95% CI: 1.054-1.150, p = 0.014), and CABG (aOR: 1.46, 95% CI: 1.313-1.626, p < 0.001). These patients had lower odds of cardiogenic shock (aOR: 0.91, 95% CI: 0.837-0.992, p = 0.032), but higher odds of AKI (aOR: 1.10, 95% CI: 1.013-1.193, p = 0.025) and electrical cardioversion or defibrillation (aOR: 1.18, 95% CI: 1.041-1.326, p = 0.009) when compared to non-obese patients (Table 2).

There was no difference in rate of composite revascularization between morbidly obese and non-obese patients (aOR: 0.99, 95% CI: 0.911-1.086, p = 0.905). Morbidly obese patients had lower odds of PCI (aOR: 0.92, 95% CI: 0.846-0.991, p = 0.030), but higher odds of CABG (aOR: 1.35, 95% CI: 1.170-1.559, p < 0.001) and AKI (aOR: 1.47, 95% CI: 1.333-1.610, p < 0.001) compared to non-obese patient (Table 3).

**Characteristics of NSTEMI patients**

Obese patients admitted for NSTEMI had a significantly lower mean age compared to non-obese patients (63.0 vs 69.5 years, p < 0.001). Obese patients had higher proportion of medical comorbidities (Table 1).

**Primary outcome in NSTEMI patients: in-hospital mortality**

A total of 949,985 hospitalizations involved patients with NSTEMI. The in-hospital mortality for patients with NSTEMI was 3.5% overall. Mild to moderately obese patients with NSTEMI had a lower adjusted odds ratio for mortality (aOR: 0.73, 95% CI: 0.660-0.811, p < 0.001) when compared to non-obese patients with NSTEMI. Patients with morbid obesity had no difference in mortality (aOR: 0.95, 95% CI: 0.854-1.055, p = 0.333) compared to non-obese patients (Tables 4, 5).
| Outcome                        | Mild-moderate, % | Nonobese, % | aOR (95% CI)         | p-value |
|-------------------------------|------------------|-------------|----------------------|---------|
| Primary outcome               |                  |             |                      |         |
| In-hospital mortality         | 2.0              | 3.8         | 0.73 (0.660 – 0.811) | <0.001* |
| Secondary outcomes            |                  |             |                      |         |
| Mean Length of stay, days (95% CI) | 4.8 (4.7 – 4.9) | 4.5 (4.4 – 4.5) | 0.28 (0.205 – 0.351) | <0.001* |
| Mean total hospital charges, US$ (95% CI) | 96400 (84100 – 38800) | 83800 (82200 – 85400) | 7100 (5400 – 8700) | <0.001* |
| PCI with DES                  | 36.4             | 31.2        | 1.06 (1.028 – 1.100) | <0.001* |
| PCI with BMS                  | 3.2              | 3.2         | 0.97 (0.887 – 1.051) | 0.420   |
| PCI                           | 39.3             | 34.1        | 1.05 (1.017 – 1.088) | 0.003*  |
| Revascularization             | 54.1             | 42.3        | 1.31 (1.262 – 1.350) | <0.001* |
| CABG                          | 15.0             | 8.3         | 1.65 (1.576 – 1.747) | <0.001* |
| AKI                           | 19.6             | 20.0        | 1.06 (1.014 – 1.108) | 0.011*  |
| Electrical cardioversion/defibrillation | 1.4              | 1.2         | 1.12 (0.985 – 1.284) | 0.081   |
| Cardiogenic shock             | 3.2              | 3.6         | 0.93 (0.855 – 1.016) | 0.110   |

**TABLE 4: Clinical outcomes of NSTEMI in mild to moderately obese patients**

*: Statistically significant, AKI: Acute kidney failure, aOR: adjusted odds ratio, BMS: Bare metal stent, CABG: Coronary artery bypass grafting, CI: Confidence interval, DES: Drug eluting stent, PCI: Percutaneous coronary intervention, NSTEMI: Non-ST segment elevation myocardial infarction.
## Clinical outcomes of NSTEMI in morbidly obese patients

| Outcome                          | Morbid obesity, % | Nonobese, % | aOR (95% CI) | p-value |
|----------------------------------|-------------------|-------------|--------------|---------|
| **Primary outcome**              |                   |             |              |         |
| In-hospital mortality            | 2.6               | 3.8         | 0.95 (0.854 – 1.055) | 0.333   |
| **Secondary outcomes**           |                   |             |              |         |
| Mean Length of stay, days (95% CI) | 5.4 (5.3 – 5.5)  | 4.5 (4.4 – 4.5) | 0.63 (0.536 – 0.723) | <0.001* |
| Mean total hospital charges, US$ (95% CI) | 100000 (97200 – 102900) | 83800 (82200 – 85400) | 10000 (7800 – 12100) | <0.001* |
| PCI with DES                     | 32.7              | 31.2        | 1.02 (0.983 – 1.064) | 0.269   |
| PCI with BMS                     | 2.7               | 3.2         | 0.85 (0.759 – 0.941) | 0.002*  |
| PCI                              | 35.1              | 34.1        | 1.00 (0.960 – 1.039) | 0.942   |
| Revascularization                | 46.9              | 42.3        | 1.11 (1.071 – 1.156) | <0.001* |
| CABG                             | 12.0              | 8.3         | 1.35 (1.268 – 1.437) | <0.001* |
| AKI                              | 24.9              | 20.0        | 1.32 (1.264 – 1.386) | <0.001* |
| Electrical cardioversion/defibrillation | 1.6          | 1.2         | 1.28 (1.111 – 1.465) | 0.001   |
| Cardiogenic shock                | 3.4               | 3.6         | 0.87 (0.791 – 0.962) | 0.006   |

**TABLE 5: Clinical outcomes of NSTEMI in morbidly obese patients**

*: Statistically significant, AKI: Acute kidney failure, aOR: adjusted odds ratio, BMS: Bare metal stent, CABG: Coronary artery bypass grafting, CI: Confidence interval, DES: Drug eluting stent, PCI: Percutaneous coronary intervention, NSTEMI: Non-ST segment elevation myocardial infarction.

### Secondary outcomes in NSTEMI patients

In NSTEMI, mild to moderately obese patients had a significantly lower adjusted odds for inpatient mortality compared to nonobese patients. There was no difference in mortality between morbidly obese patients and non-obese patients with NSTEMI.

### Discussion

Obesity is prevalent in patients with AMI. Although more males had AMI, obesity was associated with a higher prevalence in females with AMI. This is congruent with the overall higher prevalence of obesity in females in the US [3]. Obese patients were significantly younger on hospitalization in both the STEMI and NSTEMI groups, likely due to the association of obesity with early development of coronary disease [23, 24]. Whites, Blacks and Hispanics with AMI also had a higher proportion of obese patients suggesting that the racial disparity in obese population also reflects in these patients [3].

Among patients with STEMI, mild to moderately obese patients had lower odds of inpatient mortality. However, morbidly obese patients had higher odds of inpatient mortality compared to nonobese patients. This showed that the severity of obesity likely impacted mortality in STEMI patients. A conclusion reached by Das et al. showed that morbid obesity was independently associated with worse outcomes among patients with STEMI [9]. This finding is at variance with a study by Dhoot et al., which demonstrated lower odds of mortality in morbidly obese patients [25]. This study did not stratify AMI which could have been a confounding factor.

In NSTEMI, mild to moderately obese patients had a significantly lower adjusted odds for inpatient mortality compared to nonobese patients. There was no difference in mortality between morbidly obese patients and non-obese patients with NSTEMI.

The study demonstrated higher odds of composite revascularization in mild to moderately obese patients...
with STEMI. There was no difference in composite revascularization between morbidly obese patients and non-obese patients. This finding may be associated with better outcomes in patients with mild-moderate compared to morbidly obese patients who had STEMI. Among patients with NSTEMI, both mild-moderate and morbidly obese patients had higher odds of revascularization compared to non-obese patients.

There was increasingly higher hospital resource utilization with levels of obesity. This is seen in the rising length of hospitalization and the total hospital charges. This is similar to a study by Champagne-Langabeer et al., which showed morbidly obese patients had longer treatment times compared to other patients with MI [26]. This places significant stress on the healthcare institutions amid limited resources.

Various reasons have been postulated for the better outcome in mild to moderately obese patients including lower incidence of undernutrition, weight loss, possible presence of protective cytokine, greater metabolic reserves and possibly differing obesity phenotypes [11, 24]. We also suggest that although obesity is a risk factor for cardiovascular diseases, in patients with AMI, the earlier age of presentation as well as the statistically significant higher rates of interventions including PCI and CABG, procedures with known mortality benefits, help to offset this risk. However, the poorer outcomes in morbidly obese patients suggest that with progression of obesity, there is a proportional increase in cardiovascular risk.

Our study has some important limitations. NIS database is subject to non-randomization. The NIS is an administrative database that uses ICD-10 codes to characterize diagnoses and hospitalization events [27]. BMI could not be coded on a linear scale, as BMI ranges rather than individual BMI values are available. The disability associated with obesity could not be measured using the NIS database. Data in NIS is on hospitalizations, rather than individual patients. Hence if the same patient gets admitted on more than one occasion, that patient will be counted multiple times [28]. There is no reliable way to determine if secondary diagnoses preceded or started in the index hospitalization. NIS studies cannot establish causation, but only association.

**Conclusions**

The degree of obesity affects outcome of patients with AMI. Cardiovascular interventions during hospitalizations for AMI also varied with degree of obesity. This may have affected the outcome, especially among morbidly obese patients. The reasons for these differences are not clear. However, morbidly obese patients had poorer outcomes compared to patients with only mild-moderate obesity. Increased revascularization procedures may improve outcomes in obese patients. Further studies are required to elucidate factors responsible for this paradox as well as identifying the point at which these variables no longer improve outcomes in obese people.

**Appendices**

| **ICD-10 codes** |
|------------------|
| **Diagnosis codes** |
| STEMI | I21.0, I21.1, I21.2, I21.3 |
| NSTEMI | 121.4 |
| Obesity | E66.0, E66.1, E66.2, E66.8, E66.9, Z68.3, Z68.4 |
| **Procedure codes** |
| PTCA | 02703ZZ, 02704ZZ, 02713ZZ, 02714ZZ, 02723ZZ, 02724ZZ, 02733ZZ, 02734ZZ |
| PCI BMS | 02703D6, 02703DZ, 02704D6, 02704DZ, 02703E6, 02704E6, 02704EZ, 02703F6, 02703FZ, 02704F6, 02704FZ, 02703G6, 02703GZ, 02704G6, 02704GZ, 02713D6, 02713DZ, 02714D6, 02714DZ, 02713EZ, 02713EZ, 02714EZ, 02714EZ, 02713F6, 02713FZ, 02714F6, 02714FZ, 02713G6, 02713GZ, 02714G6, 02714GZ, 02723D6, 02723DZ, 02724D6, 02724DZ, 02723EZ, 02723EZ, 02724EZ, 02724EZ, 02723F6, 02723FZ, 02724F6, 02724FZ, 02723G6, 02723GZ, 02724G6, 02724GZ, 02733D6, 02733DZ, 02734D6, 02734DZ, 02733EZ, 02734EZ, 02733EZ, 02734EZ, 02733F6, 02733FZ, 02734F6, 02734FZ, 02733G6, 02733GZ, 02734G6, 02734GZ |
| PCI DES | 0270346, 027034Z, 0270446, 027044Z, 0270356, 027035Z, 0270456, 027045Z, 0270466, 027046Z, 0270376, 027037Z, 0270476, 027047Z, 0271346, 027134Z, 0271446, 027144Z, 0271356, 027135Z, 0271456, 027145Z, 0271366, 027136Z, 0270376, 027037Z, 0271466, 027146Z, 0272376, 027237Z, 0272466, 027246Z, 0272346, 027234Z, 0272446, 027244Z, 0272356, 027235Z, 0272456, 027245Z, 0272366, 027236Z, 027246Z, 027246Z, 0272376, 027237Z, 0272476, 027247Z, 0273346, 027334Z, 0273344, 0273343, 0273356, 027335Z, 0273456, 027345Z, 0273366, 027336Z, 0273466, 027346Z, 0273376, 027337Z, 027045Z, 027045Z, 0272346, 027234Z |
| IABP | 5A02210, 5A02110 |
| PEAD                  | 02HA0RJ, 02HA3RJ, 02HA4RJ, 5A02116, 5A0211D, 5A02216, 5A0221D, 02HA3RZ, 5A02216 |
|----------------------|----------------------------------------------------------------------------------|
| Intra coronary artery thrombolytic infusion | 3E07017, 3E07317 | 0210093, 0210098, 0210099, 021009C, 021009F, 021009W, 02100A3, 02100A8, 02100A9, 02100AC, 02100AF, 02100AW, 0211093, 0211098, 0211099, 021109C, 021109F, 021109W, 02110A3, 02110A8, 02110A9, 02110AC, 02110AF, 02110A, 0212093, 0212098, 0212099, 021209C, 021209F, 021209W, 02120A3, 02120A8, 02120A9, 02120AC, 02120AF, 02120AW, 0213093, 0213098, 0213099, 021309C, 021309F, 021309W, 02130A3, 02130A8, 02130AC, 02130AF, 02130AW |
| Comorbidities        |                                                                                   |
| Dyslipidemia         | E78                                                                                |
| Old MI               | I252                                                                               |
| Old PCI              | Z9861                                                                              |
| Old CABG             | Z951                                                                               |
| Old pacemaker        | Z950                                                                               |
| Atrial fibrillation/flutter | I48                                      |
| Chronic obstructive pulmonary disease | J41, J42, J43, J44 |
| Old stroke           | I69                                                                                |
| Hypertension         | I10                                                                                |
| Peripheral vascular disease | I739                                      |
| Hypothyroidism       | E03                                                                                |
| Diabetes Mellitus Type 1 & 2 | E10, E11                          |
| Congestive heart Failure | I50                                              |
| Chronic Kidney Disease | N18                                      |
| Liver disease        | K70, K71, K72, K73, K74, K75, K76, K77                                           |
| Electrolyte derangement | E870, E871, E872, E873, E874, E875, E876                                      |
| Oxygen dependence    | Z9981                                                                              |
| Smoking              | ZB7891, F17200                                                                     |
| Anemia               | D50, D51, D52, D53, D55, D56, D57, D58, D59, D60, D61, D62, D63, D64               |

**TABLE 6: Used ICD-10 codes**

- ACS: Acute Coronary Syndrome
- STEMI: ST Elevation Myocardial infarction
- NSTEMI: Non-ST Elevation Myocardial Infarction
- UA: Unstable Angina
- RA: Rheumatoid Arthritis
- MI: Myocardial Infarction
- PCI: Percutaneous Coronary Intervention
- CABG: Coronary Artery Bypass Graft
- PTCA: Percutaneous Transluminal Coronary Angioplasty
- PCI DES: Percutaneous Coronary Intervention with Drug Eluting Stent
- PCI BMS: Percutaneous Coronary Intervention with Bare Metal Stent
- IABP: Intra-aortic Balloon Pump
- PEAD: Percutaneous External Assist Devices
Additional Information

Disclosures

Human subjects: Consent was obtained by all participants in this study. N/A issued approval N/A. The NIS database does not contain patient identifiers. Since 2012, the NIS has also removed state level and hospital identifiers. This has enhanced patient protection and anonymity. This study was exempt from Institutional Review Board approval. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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