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Research Article

Sepsis Impacts Survival in Medicare Beneficiaries Presenting with Acute Myocardial Infarction

Steven D. Culler[1]*, April W. Simon[2] and Aaron D. Kugelmass[3]

[1]*Rollins School of Public Health, Emory University, USA*

[2]*AWS Research, LLC, USA*

[3]*Baystate Health, UMASS Chan Medical School, USA*

***Corresponding author**

Steven D. Culler, Rollins School of Public Health, Emory University, 1518 Clifton Road NE, Atlanta GA 30322, USA

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Keywords

- AMI; PCI; Sepsis; In-hospital Mortality Rate; Medicare Beneficiaries

Abstract

Background: Aggressive measures to rapidly identify acute myocardial infarction (AMI) patients and shorten door-to-balloon (D2B) time risks missing the diagnosis of alternative and/or concomitant medical conditions, including sepsis. This may delay initiation of appropriate therapy, for diseases like sepsis which account for 13.5% of all hospital admissions. The purpose of this study is to identify the impact of sepsis in patients with acute myocardial infarction, as well as the timing of percutaneous coronary intervention on mortality.

Methods: Retrospective analysis of 2018 and 2019 Centers for Medicare and Medicaid Services-linked data identified all Medicare beneficiaries (MBs) hospitalized for an AMI (STEMI, NSTEMI, or Type II). The key outcome variables were observed and predicted hospital morality rates, and the timing of PCI procedure.

Results: In total 859,794 MBs were hospitalized with AMI Present on Admission (POA) with an mortality rate of 8.2%. Of these procedures, nearly 14% also had sepsis POA. When sepsis was POA, 20.9% of MBs died during their AMI hospitalization compared to 6.2% of MBs without sepsis POA. MBs with sepsis who had their PCI on the day of admission all experienced higher observed than predicted mortality rates regardless of the type of AMI with the difference between observed and predicted mortality rates ranging from 10.7 percentage points for Type II AMI to 6.63 percentage points for MBs with STEMI. Conversely MBs with sepsis who received a PCI after their admission day, all had observed mortality rates that were lower than predicted mortality rates.

Conclusions: MBs with AMI who are septic on admission are 3.3 times more likely to die than those MBs without sepsis. A comparison of observed and predicted mortality rates among MBs with sepsis suggest that mortality rates for AMI patients with sepsis can be improved by delaying the timing of PCI.

BACKGROUND

Efforts to reduce the time from first medical contact to reperfusion therapy for patients with acute myocardial infarction including out of hospital STEMI activation, and accelerated diagnostic and care pathways in the emergency room have been broadly adopted and have reduced the time to definitive therapy. However, the expedited transfer of AMI patients to the cardiac cath lab for primary percutaneous coronary intervention (PCI) expose some patients to unnecessary procedures and potentially delay appropriate alternative therapies [1]. Expedited cardiac catheterization in patients with false positive STEMI diagnosis has been associated with to suboptimal outcomes [2,3]. At the same time, cardiac catheterization and PCI in patients with concomitant acute illness and acute myocardial infarction may delay the additional diagnosis and initiation of other therapies and can result in increased mortality [1,2].

Sepsis is a common condition accounting for upward of 14% of hospital admissions, and thus is more common than myocardial infarction in admitted patients [4,5]. Sepsis is associated with high inpatient mortality [4], higher health care spending [6,7], more disabilities [8], and lower quality of life [9]. However, sepsis lacks a distinct gold-standard test, resulting in inconsistencies in the recognition of sepsis in clinical settings. Early recognition and response can reverse the inflammatory response and improve patient outcomes [10]. Failure to initiate appropriate therapy is strongly correlated with an increased morbidity and mortality [11]. For every one-hour delay in administration of an antibiotic treatment for severe sepsis or severe shock, patient survival decreases incrementally [12]. Many septic patients are not diagnosed at an early stage when aggressive treatment has the potential to reverse the course of infection and the associated inflammatory response [5]. Quality initiatives to increase consistent early diagnosis and treatment of sepsis are common in the US.

The purpose of the study is to report the contemporary incidence and mortality rates of acute myocardial infarction in the Medicare population, as well as any impact of concomitant sepsis at the time of admission. Additionally, this study evaluates the impact of PCI, and its' timing on mortality. Specifically, this study will report observed and predicted mortality rates by type of AMI (STEMI, NSTEMI, or Type II), timing of first PCI (no PCI, admission day PCI, or PCI after admission day), and by whether or not the patient had sepsis on admission.

METHODS

Data Source

Centers for Medicare and Medicaid Service's (CMS) Inpatient Standard Analytical Files (IPSAF) linked data for 2018, and 2019 are the primary data sources for this retrospective analysis. The IPSAF file includes all fee-for-service claims data submitted to the Medicare program. This study uses only hospital inpatient claims. We used the IPSAF files because they contained information related to the admission date, discharge date, discharge status, 25 International Classification of Disease -10- Clinical Modification ICD-10-CM procedure and diagnosis codes, a code indicating whether the diagnosis code was present-on-admission, and the date that each procedure took place. In addition, the Medicare Provider Analysis and Review (MedPAR) file for fiscal years 2018 and 2019 was analyzed to determine US hospitals that performed at least one Percutaneous Coronary Intervention (PCI) procedure on Medicare beneficiaries in each year. The MedPAR file is an administrative database maintained by CMS that contains all claims submitted by hospitals for inpatient services provided to all Medicare beneficiaries (MBs) in both the traditional program (Part A) and the Medicare Advantage Plan (Part C).

Study Population

The population in this study consisted of any MB that was hospitalized with an acute myocardial infarction POA in a hospital that performed at least one PCI on a MB in each calendar year. The unit of analysis is the hospitalization. As a result, a single MB could be in the study population more than once if they had more than one AMI admission during the study period. AMI hospitalizations were identified by ICD-10-CM diagnosis codes (see Appendix A for list of ICD-10-CM codes used to identify any AMI). A Medicare Beneficiary's AMI hospitalization was excluded from the study population if the POA indicator variable was not coded 'Yes'. After exclusion MBs admitted to a hospital not performing PCIs, a total of 859,794 AMI hospitalizations met the study inclusion criteria during the study period (423,687 in 2018 and 436,107 in 2019).

Key Outcomes and Study Variables

The key outcomes in this study are the number of AMI hospitalizations by type of AMI, with and without Sepsis POA and whether or not the MB was discharged alive or died during their AMI hospitalization. In-hospital mortality was determined using the discharge status variable indicating that the patient expired during the hospitalization. The type of AMI admission for each MB's hospitalization was defined as follows. First, ICD-10-CM diagnosis codes were used to determine the type of AMI the MB presented with at admission: 1) ST-segment elevation myocardial infarction (STEMI); 2) Non-ST-segment elevation myocardial infarction (N-STEMI); or 3) Type II AMI. In the case where a MB's ICD-10-CM diagnosis codes indicated that more than one type of AMI POA, the MB was categorized as a STEMI patient if any STEMI code was POA. The MB was categorized as a N-STEMI when the record indicated that both N-STEMI and Type II were POA. The MB was categorized as a Type II AMI if that was the only type of AMI POA. Sepsis POA was identified using ICD_10 CM diagnosis codes and the POA indicator equal 'yes'. Finally, ICD-10CM procedure codes were used to identify if the MB underwent a PCI procedure during the hospitalization. If the MB received a PCI during the hospitalization, the hospital admission date and the first PCI procedures date were used to determine if the PCI procedure occurred on the day of admission or sometime after the day of the admission. As a result, for each type of AMI POA, the MB could be in one of six categories depending on the timing of their PCI and whether or not the patient had Sepsis POA.

Statistical Analysis

Counts of MBs and means were used to report patient statistics and observed mortality rates by their type of AMI, whether or not the MB had sepsis on admission, and the timing of any PCI during the admission, for the whole study population. Multivariate logistic regression models were used to estimate the predicted mortality rate for all MBs by their type of AMI, whether or not the MB had sepsis on admission, and the timing of any PCI during the admission. The logistic regression model includes two control variables for the type of AMI (STEMI POA, or NSTEMI POA (TYPE II AMI was reference category), a variable for whether the MB was admitted with Sepsis POA (sepsis not POA was the reference category), two variables to control for the time of the PCI (PCI on day of admission, PCI any day after the admission day, (MBs not undergoing a PCI during their AMI hospitalization was the reference category). The logistic regression model also controlled for the MB's gender, age category, race, and 23 comorbid conditions identified by ICD-10-CM diagnoses codes. The predicted mortality rate of all categories reported in the results was calculated by using a mean value of the predicted mortality rate from the logistic regression analysis for of all MBs in the category. Differences were considered statistically different if the p-value was less than or equal to 0.01. All analyses were performed with SAS 9.4 (SAS Institute, Cary, North Carolina).

RESULTS

A total of 859,794 MBs were hospitalized with an AMI during the two-year study period. (Table 1). Over 57% (493,052 MBs) of the population were hospitalized with a NSTEMI and slightly less than 15% (128,704) presented with a STEMI. The remaining 28% (238,038) myocardial infarctions were identified as Type II AMI. Importantly, approximately 14% (119,947) of patients hospitalized with a primary diagnosis of acute myocardial infarction also had sepsis at the time of admission. The proportion of AMI patients with concomitant sepsis ranged from 4.8% of STEMIs to a high of 26.50% of MBs hospitalized with Type II infarctions.

Seventy-three percent (627,960) of patients did not undergo a PCI procedure during their hospitalization (Table 2a). The percentage of patients who did not undergo PCI during the index hospitalization ranged from 35.3% of STEMIs to 98.4% of patients with a Type II MI. Over 95% of patients with sepsis did not undergo PCI during the hospitalization as compared to 69.5% of patients without concomitant sepsis.

Table 2b depicts the results of patients undergoing PCI. Among the STEMI patients that did have PCI, 87.5% (71,725/82,013) had their PCI the day of admission if they did not have concomitant sepsis, as opposed to 78.8% (957/1,315) of patients who had both STEMI and sepsis. Alternatively, 65.5% (92,212/140,589)

Table 1: Count and Proportion of Hospitalizations by Type of AMI for MBs with and without Sepsis Present on Admission.			
AMI Type	**Sepsis, Not POA**	**Sepsis POA**	**Total MBs**
STEMI	122,523 (14.25%)	6,181 (0.72%)	128,704 (14.97%)
NSTEMI	442,357 (51.45%)	50,695 (5.09%)	493,052 (57.35%)
Type II AMI	174,967 (20.35%)	63,071 (7.34%)	238,038 (27.67%)
All AMIs	739,847 (86.05%)	119,947 (13.95%)	859,794 (100.00%)

Note: Number in the parenthesis in each cell is the proportion of MB in that cell out of all MBs admitted with an AMI present on admission during the study period

Table 2a: Count and Proportion of Hospitalizations by Type of AMI and PCI Procedure for MBs with and without Sepsis Present on Admission.

	No PCI During Admission			**PCI During Admission**			**Total MBs**		
AMI Type	**Sepsis, Not POA**	**Sepsis POA**	**Total No Sepsis & Sepsis**	**Sepsis Not POA**	**Sepsis POA**	**Total No Sepsis & Sepsis**	**Sepsis Not POA**	**Sepsis POA**	**Total**
STEMI	40,510	4,866	45,376 (35.3%)	82,013	1,315	83,328 (64.74%)	122,523	6,181	128,704
NSTEMI	301,768	46,689	348,457 (70.7%)	140,589	4,006	144,595 (29.3%)	442,357	50,695	493,052
Type II	171,632	62,495	234,127 (98.4%)	3,335	576	3,911 (1.6%)	174,967	63,071	238,038
Total AMIs	513,910 (69.5%)	114,050 (95.1%)	627,960 (73.0%)	226,837 (30.5%)	5,897 (4.9%)	231,834 (27.0%)	739,847	119,947	859,794

Note: Number in the parenthesis in each cell is the proportion of that AMI category by PCI type.
POA = present on admission

Table 2b: Count and Proportion of Hospitalizations by Type of AMI and PCI Procedure Timing.

	PCI on Admission Date			**PCI after Admission Date**			**Total PCIs**		
AMI Type	**Sepsis, Not POA**	**Sepsis POA**	**Total No Sepsis & Sepsis**	**Sepsis, Not POA**	**Sepsis POA**	**Total No Sepsis & Sepsis**	**Sepsis Not POA**	**Sepsis POA**	**Total No Sepsis & Sepsis**
STEMI	71,725 (87.5%)	957 (72.8%)	72,682	10,288 (12.5%)	358 (27.2%)	10,646	82,013 (98.4%)	1,315 (1.6%)	83,328
NSTEMI	48,468 (34.5%)	554 (13.8%)	49,022	92,121 (65.5%)	3,452 (86.2%)	95,573	140,589 (97.2%)	4,006 (2.8%)	144,595
Type II	400 (12.0%)	41 (1.2%)	441	2,935 (88.0%)	535 (92.9%)	3,470	3,335 (85.3%)	576 (14.7%)	3,911
Total AMIs	120,593 (53.4%)	1,552 (26.3%)	122,145 (52.7%)	105,344 (46.6%)	4,345 (73.7%)	109,689 (47.3%)	225,937 (97.5%)	5,897 (2.5%)	231,834

of NSTEMI patients without sepsis who underwent PCI had their procedure at least one day after the admission date compared to 86.2% (3,452/4,006) of patients with sepsis. Finally, among the 1.6% of patients with a Type II AMI that underwent a PCI over 88% (2,935/3,335) had their PCI at least one day after the admission date if they did not have sepsis, as opposed to 92.8% (535/576) of patients with sepsis.

Table 3 reports observed in-hospital mortality rates among MB's by Type of AMI and by whether or not the MB had Sepsis POA. Table 3 indicates that the overall observed mortality rate for all MBs in the sample was 8.23% and ranged from a high of 12.98% for all MBs with a STEMI to a low of 7.14% for all MBs with NSTEMI. Having Sepsis POA increased the observed mortality rate by more than 3.4 times (observed mortality rate was 20.9% for all MBs hospitalized with an AMI and Sepsis POA compared to 6.17% for MBs without sepsis POA). In addition, the observed difference in mortality rates between MBs with and without Sepsis POA ranged from 3.4 times for MBs with Type II AMI to 4.6 times for MB admitted with NSTEMI.

Table 4 reports the estimated odds-ratio and 95% coefficient interval of the multi-variate regression model predicting mortality for all MBs with an AMI hospitalization controlling for Sepsis POA, type of AMI, the timing of the PCI procedure, as well as the MB age group, gender, race, and 23 co-morbidity conditions. The results from this regression indicate that MBs with Sepsis POA were more likely (Odds Ratio = 1.39X, 95% CI

Table 3: Observed Mortality Rates among MB's Hospitalization by Type of AMI POA and by whether or not the MB had Sepsis POA.

AMI Type	Sepsis, Not POA	Sepsis, POA	Total by AMI Type
STEMI	11.47%	42.86%	12.98%
NSTEMI	5.22%	23.93%	7.14%
Type II	4.89%	16.31%	7.91%
Total AMIs	6.17%	20.90%	8.23%
POA = present on admission			

Table 4: Predicted Odds Ratio and 95% Coefficient Intervals from Logistic Regression Model Predicting In-Patient Mortality During for MBs during their AMI Hospitalization.

	MBs Admitted with any type AMI
Volume	859,794
Mortality	70,744 (8.23%)
Septicemia POA	1.39 (1.36 – 1.42)
STEMI POA	4.45 (4.42 – 4.69)
NSTEMI POA	1.69 (1.65 – 1.72)
(Reference group: TYPE II AMI POA)	
PCI on Admission Day	0.42 (0.41 – 0.44)
PCI on a day after Admission Day	0.42 (0.41 – 0.44)
Reference group: No PCI during AMI admission	
Female	0.98 (0.96 0.99)
Non-White	0.95 (0.93 – 0.97)
Age 65-69	1.10 (1.06 – 1.14)
Age 70-74	1.34 (1.29 – 1.39)
Age 75-79	1.62 (1.56 – 1.68)
Age 80-84	1.90 (1.83 – 1.97)
Age > 84	2.28 (2.20 – 2.36)
(Reference group: age < 65)	
Shock POA	4.29 (4.20 – 4.39)
Acute Respiratory Failure POA	3.18 (3.12 – 3.24)
Ventricular Tachycardia	1.84 (1.79 – 1.88)
Dialysis Dependence POA	1.67 (1.61– 1.72)
Chronic Liver Disease POA	1.33 (1.27 – 1.40)
Malnutrition	1.28 (1.24 – 1.31)
Chronic Kidney Disease POA	1.21 (1.19 – 1.23)
Prior CABG	1.08 (1.05 – 1.11)
Diabetes	1.04 (1.02 – 1.06)
COPD	0.96 (0.85 – 0.99)
Severe Morbid Obesity	0.95 (0.92 – 0.99)
Anemia POA	0.94 (0.92 – 0.95)
Cardiomyopathy	0.93 (0.90 – 0.96)
Acute Heart Failure	0.93 (0.91 – 0.95)
Chronic Respiratory Failure	0.92 (0.85 – 0.99)
Prior CVA	0.92 (0.89 – 0.95)
Atrial Fibrillation	0.91 (0.88 – 0.93)
Long-Term Use of Steroids	0.80 (0.74 – 0.86)
Obstructive Sleep Apnea	0.77 (0.75 – 0.80)
Prior PCI	0.76 (0.74 – 0.78)
Depression	0.76 (0.74 – 0.78)
Hypertension	0.73 (0.72 – 0.75)
Chronic Ischemic Heart Disease	0.71 (0.69 – 0.72)
C – Stat	0.814

1.36X to 1.42X) to die during their AMI hospitalization than MBs without Sepsis POA. Compared to MBs with TYPE II AMI POA, MBs acute coronary syndromes (STEMI and NSTEMI) Compared to MBs not undergoing a PCI during their AMI hospitalization, MBs were significantly less likely to die if they received a PCI during their admission day (Odds Ratio = 0.42X, 95% CI 0.41X to 0.44X) and if they received an PCI at least one day after admission (Odds Ratio = 0.42X, 95% CI 0.41X to 0.44X). The demographic variables indicate that female MBs were less likely than males to die during their AMI hospitalization (Odds Ratio = 0.98X, 95% CI 0.96X to 0.99X) and non-white were less likely than whites to die during their AMI hospitalization (Odds Ratio = 0.95X, 95% CI 0.93X to 0.97X). Compared to MB under age 65, each older MBs age group were significantly more likely to die during their AMI hospitalization with the odds-ratio increasing from 1.10X for MBs in age 65-69 to an odds ratio of 2.28X for MBs age greater 84. Nine comorbid conditions were associated with significantly higher risk of mortality. The four largest odds ratios among the comorbid conditions associated with higher mortality were for 1) shock POA – odds ratio 4.29X; 2) acute respiratory failure POA – odds ratio 3.18X; 3) ventricular tachycardia – odds ratio 1.84X; and 4) dialysis dependence POA – odds ratio 1.67X. On the other hand, among MBs hospitalized with AMI POA, fourteen comorbid conditions were associated with significantly lower risk of mortality, five of the estimated odds ratios were associated with a reduction in the risk of mortality by more than 20 percent (i.e., the estimated odds ratio was less than .80X). The estimated odds ratios in Table 4 were used to calculate the risk-adjusted predicted mortality rate for each MB in the sample.

Figures 1-3 report observed and predicted mortality rates by whether or not the MBs had Sepsis POA and the timing of their PCI procedure for STEMI, NSTEMI, and TYPE II AMI, respectively. A review of Figure 1 indicates that for MBs with a STEMI without Sepsis POA the observed and predicted mortality rates were nearly identical within each of the three different PCI procedure times. For example, MBs undergoing a PCI on the day of admission with a STEMI without Sepsis POA had an observed mortality rate of 7.32% compared to a predicted rate of 7.60%. This was also true for MB with a STEMI without Sepsis POA that did not receive a PCI during their hospitalization, except both the

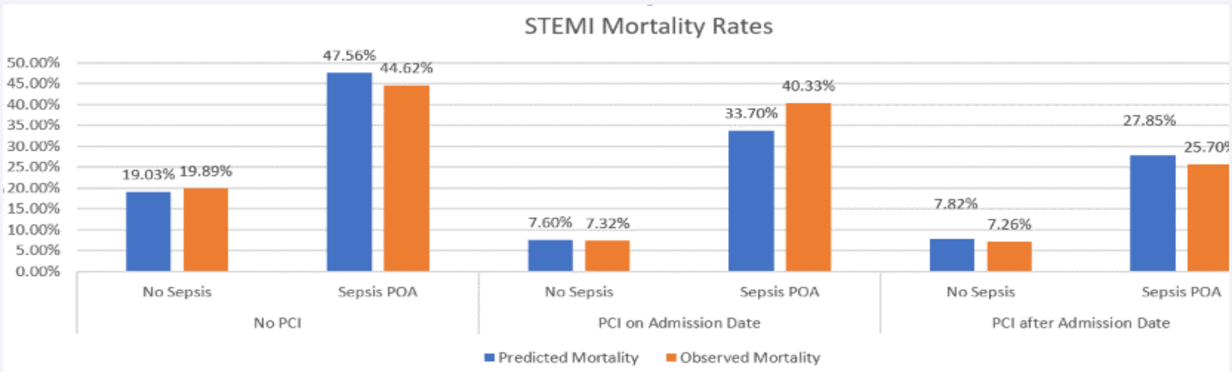

Figure 1 Observed and Predicted Mortality Rate for MBs with STEMI with and without Sepsis POA by timing of PCI procedure.

observed and predicted rates were much higher; 19.89% and 19.03% respectively. MBs with STEMI and Sepsis POA who did not undergo a PCI procedure during their AMI hospitalization had the highest predicted mortality rate (45.56%) and observed mortality rate (44.62%) compared to MBs with STEMI and Sepsis POA in the other two PCI time frames. Importantly, MBs with a STEMI and Sepsis POA who underwent their PCI on the day of admission had a higher observed mortality rate (40.33%) than predicted (33.70%). The opposite was true for this group of MBs that underwent their PCI after their admission date: observed mortality (25.70%) versus predicted mortality rate (27.85%).

Figure 2 indicates that among MBs with NSTEMI without Sepsis POA the observed and predicted mortality rates are similar. MBs with NSTEMI not undergoing a PCI during their hospitalization had the observed and predicted mortality rates of 7% compared to 2% for those MBs undergoing a PCI on the day of admission or on any day after the day of admission. Overall, MBs with NSTEMI and Sepsis POA have a pattern of observed and predicted mortality rates similar to that identified for MBs with STEMI. MBs not receiving a PCI procedure during their hospitalization had the highest, but similar, observed and predicted mortality rates 25.12% versus 24.79%.; Observed mortality rates (22.20%) were higher than predicted (12.29%) among MBs receiving their PCI procedure on the day of admission; and predicted mortality rate (9.84%) was higher than the observed morality rate (8.05%) among MBs receiving their PCI procedure after their admission date.

Figure 3 indicates that among MBs with Type II AMI without Sepsis POA the observed and predicted mortality rates have the same percentage points (4.91%) among MB not undergoing a PCI during their hospitalization. However, for the other two PCI time periods MBs with Type II AMI without Sepsis POA had observed mortality rates (3.75% and 3.92%) that were higher than the predicted mortality rates (1.85% and 1.97%) for MBs undergoing their PCI on the day of admission and on a day after admission, respectively. Like, MBs with NSTEMI, MBs with Type II AMI with Sepsis POA not undergoing a PCI during their hospitalization had nearly identical observed and predicted mortality rates (16.49% and 16.39%). For the other two PCI time periods, the pattern between observed and predicted mortality rates was very similar to that observed among MBs with NSTEMI. Observed mortality rate (19.51%) was more than twice the predicted mortality rate (8.79%) among MBs with Type II AMI and sepsis POA receiving their PCI procedure on the day of admission. The predicted mortality rate (6.82%) was similar than the observed morality rate (6.36%) among MBs receiving their PCI procedure after their admission date.

DISCUSSION

This study findings are based on 859,794 MBs in the traditional fee-for-service Medicare Program (enrolled in Part A and Part B) who experienced a hospitalization with an AMI during calendar years 2018 and 2019. This paper provides a national benchmark in distribution of type of AMI MBs experience: over 57% NSTEMI, followed by 28%TYPE II AMI, and 15% with a STEMI. In addition, nearly 14% of all MBs hospitalized with an AMI also had concomitant sepsis. The proportion of MBs with Sepsis POA varied from a high of 26.5% of Type II AMI to a low of 4.8% with STEMI. For comparison, a 10-year retrospective study of potential STEMI patients at one hospital found the sepsis rate to be 7.9% following review of clinical data [1]. Finally, this paper provides a national benchmark on the timing of PCI procedures, in MBs with acute myocardial infarction. Overall, approximately 83% of all MBs with an AMI did not undergo a PCI procedure during their AMI hospitalization, while approximately 14% of MBs underwent a PCI on the day of admission and another 13% received a PCI after the day of their admission. Of AMI patients with sepsis POA only 5.2% underwent a PCI procedure during their AMI hospitalization and approximately 68% of those were hospitalized with an NSTEMI, while less than 0.9% (576 of the 63,071) MBs with TYPE II AMI underwent PCI during their hospitalization.

Overall, the observed mortality rates among MBs hospitalized with any type of AMI was approximately 8.2%. The observed mortality rate varied from a high of nearly 13% for MBs admitted with STEMI to a low of 7% for MBs admitted with NSTEMI. Overall, the observed mortality rate for any MB hospitalized with an AMI and concomitant sepsis was over 3.1 times higher than that for MB 's without sepsis. Those with a NSTEMI and Sepsis POA were nearly 5.6 times more likely to die during their hospitalization than MBs with NSTEMI without Sepsis POA.

Figure 1 through Figure 3 compare observed and predicted mortality rates for MBs by type of AMI, with and without

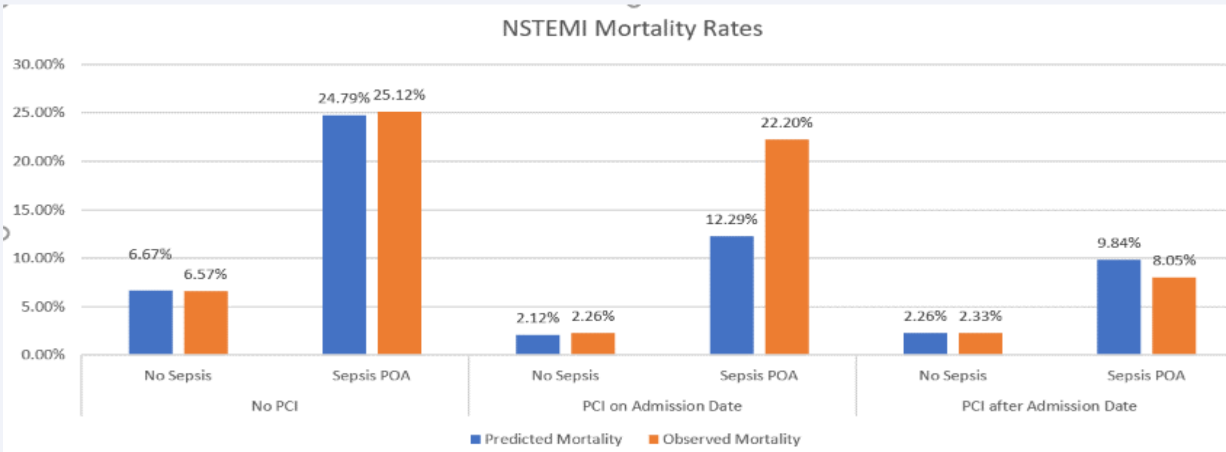

Figure 2 Observed and Predicted Mortality Rate for MBs with NSTEMI with and without Sepsis POA by timing of PCI procedure.

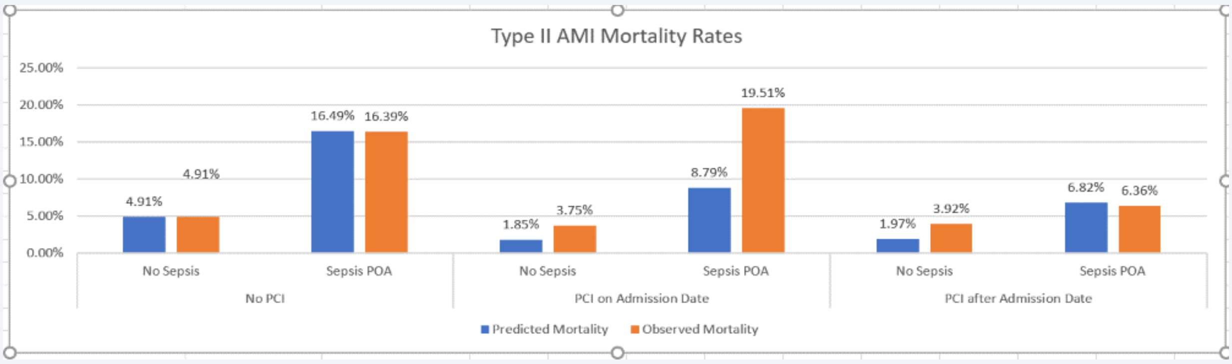

Figure 3 Observed and Predicted Mortality Rate for MBs with Type II AMI with and without Sepsis POA by timing of PCI procedure.

Sepsis POA, and by the timing of any PCI procedure during the hospitalization. Several key take-aways can be drawn from these figures regarding MB presenting with both AMI and sepsis. First, MBs with sepsis POA had higher rates of both observed and predicted mortality regardless of type of AMI or PCI timing. Secondly, MBs with Sepsis POA that did not undergo a PCI during their hospitalization had higher predicted mortality rates than those MBs with Sepsis POA that received a PCI regardless of the type of AMI, suggesting case selection amongst practitioners. Additionally, the observed mortality rates were less than or equal to the predicted for those not receiving a PCI regardless of type of AMI. This suggests that physician clinical judgement is appropriate in not sending patients presenting with both AMI and sepsis for PCI. The logistic regression model predicting mortality identifies co-morbid conditions that were associated with higher odds of mortality (see Table 4 for list of co-morbid conditions with odds-ratio significantly greater than 1.0X). Importantly for those patients with AMI and sepsis at the time of admission, those that had their PCI on the day of admission all experienced significantly higher observed than predicted mortality rates regardless of the type of AMI. The difference between observed and predicted mortality rates ranged from10.72 percentage points (19.51% vs 8.79%) for Type II 9.91percentage points (22.20% vs 12.29%) for NSTEMI; and 6.63 percentage points (40.33% vs 33.70%) for STEMI. This suggests that after controlling for age, gender, race and 23 co-morbid conditions MBs presenting with AMI and sepsis that on the undergo PCI day of admission day have worse outcomes than expected. It appears that when possible, delaying PCI in patients with acute myocardial infarctions and sepsis results in better outcomes. Beyond selection bias, this may be due to the ability to treat the underlying condition(s). This is further suggested by the observation that by septic patients who received PCI after their admission day have observed mortality rates lower than predicted regardless of AMI type.

This analysis has several limitations. First, the time of admission and time of procedures in our data set are reported as calendar dates without any knowledge of hours. As a result, it is possible that a MB was admitted to the hospital one day just prior to midnight and had a PCI procedure just after midnight. In our data this patient would have been recorded as having had their PCI procedure on a day after their admission day. A second limitation is that there were no procedure codes for antibiotic delivery in Medicare data sets until October 1, 2021. As a result, some MBs with Sepsis POA might have received an antibiotic prior to undergoing their PCI, but still had their PCI on the day of admission. Having information on the time of antibiotic administration relative to both admission with sepsis and the PCI might improve the risk-adjusted mortality models. A third limitation is that this study is limited to the information available in administrative databases. As a result, MBs co-morbid

Appendix A: ICD-10-CM codes used to identify any AMI.	
Type of AMI	**Diagnostic Codes**
STEMI	Dx Code = (I2101, I2102, I2109, I2111, I2119, I2121, I2129, I213, or I219) and POA = Yes
NSTEMI	Dx Code = I214 and POA = Yes
TYPE II AMI	Dx Code = I21A1 and POA = Yes

conditions depend on how well hospitals code their medical records. However, this limitation is mitigated by the fact that the administrative data set contains up to 25 procedures and diagnostic codes and that the estimates of risk adjusted mortality rates are based on over 850,000 MBs with nearly 71,000 in-patient deaths during the study period.

CONCLUSION

MBs who are septic on admission and have any AMI (STEMI/NSTEMI/type II) are more likely to die than those without sepsis (20.9% vs. 6.2%). The risk adjusted odds ratio suggest that after controlling for numerous demographic and co-morbid factors the odds of mortality are higher for MBs with Sepsis POA (1.39X), Mortality odds ratios are 4.45X and1.69X, for STEMI and NSTEMI respectively. Myocardial infraction patients with sepsis POA that underwent PCI had notably higher mortality than expected, this trend was reversed when the PCI in the myocardial infarction patient with concomitant sepsis if the procedure was conducted on the day of submission. For those myocardial infarction patients presenting with concomitant sepsis, early recognition and presumed treatment of the infection prior to PCI is beneficial. Emergency and cardiology physicians should be on alert for elderly acute myocardial infarction patients also having sepsis.

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