Prevalence, Causes, and Predictors of 30-Day Readmissions Following Hospitalization With Acute Myocardial Infarction Complicated By Cardiogenic Shock: Findings From the 2013–2014 National Readmissions Database

Ahmed N. Mahmoud, MD;* Islam Y. Elgendy, MD;* Mohammad K. Mojadidi, MD; Siddharth A. Wayangankar, MD; Anthony A. Bavry, MD; R. David Anderson, MD; Hani Jneid, MD; Carl J. Pepine, MD

Background—Prior studies have shown that survivors of acute myocardial infarction (AMI) complicated by cardiogenic shock are likely to have increased risk of readmissions in the early post-discharge period. However, the contemporary prevalence, reasons, and predictors of 30-day readmissions are not well known.

Methods and Results—Hospitalizations for a primary diagnosis of AMI complicated by cardiogenic shock, and discharged alive, were identified in the 2013 and 2014 Nationwide Readmissions Databases. Prevalence and reasons for 30-day unplanned readmissions were investigated. A hierarchical logistic regression model was used to identify independent predictors of 30-day readmissions. Among 1 116 933 patient hospitalizations with AMI, 39 807 (3.6%) had cardiogenic shock and were discharged alive. Their 30-day readmission rate was 18.6%, with a median time for readmission 10 days post discharge. Predictors of readmission included: non–ST-segment elevation myocardial infarction, female sex, low-income status, nonprivate insurance, chronic renal failure, long-term ventricular assist device or intra-aortic balloon placement, and tachyarrhythmia. The majority of readmissions were attributable to cardiac-related causes (52%); heart failure being the most frequent cardiac cause (39% of all cardiac causes). Noncardiac-related readmissions included infections (14.9%), bleeding (5.3%), and respiratory causes (4.9%). The median cost per readmission was $9473 US dollars ($5037–20 199).

Conclusions—Among survivors of AMI complicated by cardiogenic shock who were discharged from hospital, almost 1 in 5 are readmitted at 30 days, mainly because of cardiac reasons such as heart failure and new AMI. The risk of readmission was associated with certain baseline patient/hospital characteristics. (*J Am Heart Assoc*. 2018;7:e008235. DOI: 10.1161/JAHA. 117.008235.)

Key Words: cardiogenic shock • heart failure • myocardial infarction • readmission

Cardiogenic shock complicating acute myocardial infarction (AMI) portends a poor prognosis. In the era before coronary revascularization, this setting was often considered fatal. For example, in the GUSTO-I (Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries) study[1] and the SHOCK (Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock) registry,[2] only 40% of patients survived the hospitalization. With increased prevention measures and adoption of revascularization, in-hospital survival rates improved. In an analysis from the National Registry of Myocardial Infarction, in-hospital survival was ≈59% in 2004.[3] A more recent analysis of the NCDR-ACTION registry for 2007–2011 suggested that 2 of 3 such patients survived the index hospitalization.[4] Despite advances in anticoagulation and mechanical support devices over the past few years, the in-hospital mortality rate has been ≈30% in recent years.[5,6] With more patients surviving their index hospitalization, data regarding short- and longer-term prognosis of this high-risk population have been limited. An analysis from the NCDR-ACTION registry suggested that these patients have a

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Clinical Perspective

What Is New?

- Rates of early readmission after acute myocardial infarction complicated by cardiogenic shock remains high, with ≈1 of 5 patients readmitted within 30 days of discharge.
- Common causes of 30-day readmission are cardiovascular, with the majority of readmissions related to heart failure exacerbation and new myocardial infarction.
- Certain baseline patient characteristics, in-hospital complications, and hospital characteristics independently predicted 30-day hospital readmissions rates.

What Are the Clinical Implications?

- Future studies are required to evaluate the effect of targeting various predictors of 30-day readmissions in patients with acute myocardial infarction complicated by cardiogenic shock on readmission rates.
- Assessment of the impact of a multidisciplinary team approach for patients with acute myocardial infarction complicated by cardiogenic shock is warranted given the evidence of a strong correlation between noncardiac comorbidities, such as diabetes mellitus and chronic kidney disease, and 30-day readmissions rates.

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higher adjusted risk of mortality and/or hospitalization at 60 days but not at 1 year.[7] However, the information in this area is limited and the underlying reasons for readmissions are unclear. To better address this knowledge gap, we aimed to determine the prevalence, predictors, and reasons for readmission among AMI hospitalizations complicated by cardiogenic shock using "real-world" contemporary data from the Nationwide Readmissions Databases (NRD).

Methods

The data that support the findings of this study are available from the corresponding author upon reasonable request. Institutional review board approval was not required given the public nature of the NRD database, with the absence of any personal identifying information.

Data Source

Data were obtained from the 2013 to 2014 NRD. The NRD is part of the all-payer databases developed by the Agency for Healthcare Research and Quality for the Healthcare Cost and Utilization Project (HCUP). The NRD is created from the State Inpatient Databases and represents ≈50% of all US hospitalizations. Unweighted, the NRD contains data from ≈17 million discharges per year and weighted it estimates roughly

36 million discharges, excluding rehabilitation and long-term acute care facilities. Discharge weights are provided to estimate national estimates. The NRD contains verified patient linkage numbers that can be used to track a patient across hospitals within a state. However, the patient linkage numbers do not track the same person from 1 year into another.

Study Population

The NRD was used to identify patients hospitalized with a primary diagnosis of ST-segment elevation myocardial infarction (STEMI) (*International Classification of Diseases, Ninth Edition, Clinical Modification* [*ICD-CM-9*] codes 410.1x, 410.2x, 410.3x, 410.4x, 410.5x, 410.6x, 410.8x, and 410.9x) or non–ST-segment elevation myocardial infarction (NSTEMI) (*ICD-CM-9* code 410.7x) during the years 2013 and 2014. We included only those with a primary diagnosis of STEMI or NSTEMI during the index hospitalization since this represents the primary reason for the hospitalization, in an attempt to exclude hospitalizations with type 2 AMI.[8,9] Cardiogenic shock was identified using the *ICD-CM-9* code 785.51. Hospitalization records were excluded if: (1) patients were younger than 18 years; (2) the patient died during the index hospitalization; or (3) the discharge month was December since 30-day readmission data would be lacking (Figure 1).

Patient and Hospital Characteristics

Baseline patient characteristics included demographics (age, sex, median household income by ZIP code, and primary expected payer), weekend versus weekday admission, and other relevant comorbidities (eg, smoking, dyslipidemia, atrial fibrillation, known coronary artery disease, family history of coronary artery disease, prior myocardial infarction, prior percutaneous coronary intervention, and prior coronary artery bypass grafting) were identified using the corresponding *ICD-CM-9* codes (Table 1). Hospital-related characteristics such as bed size (small, medium, and large), location (urban versus rural), and teaching status were also identified.

Outcome Measure

The primary outcome of interest for this study was 30-day all-cause unplanned hospital readmission. Readmissions were captured according to methodology recommended by the HCUP.[10] If a record had >1 readmission within 30 days of discharge, only the first readmission was included. Transfer to another hospital was not considered as a readmission. Time to readmission was calculated as the number of days
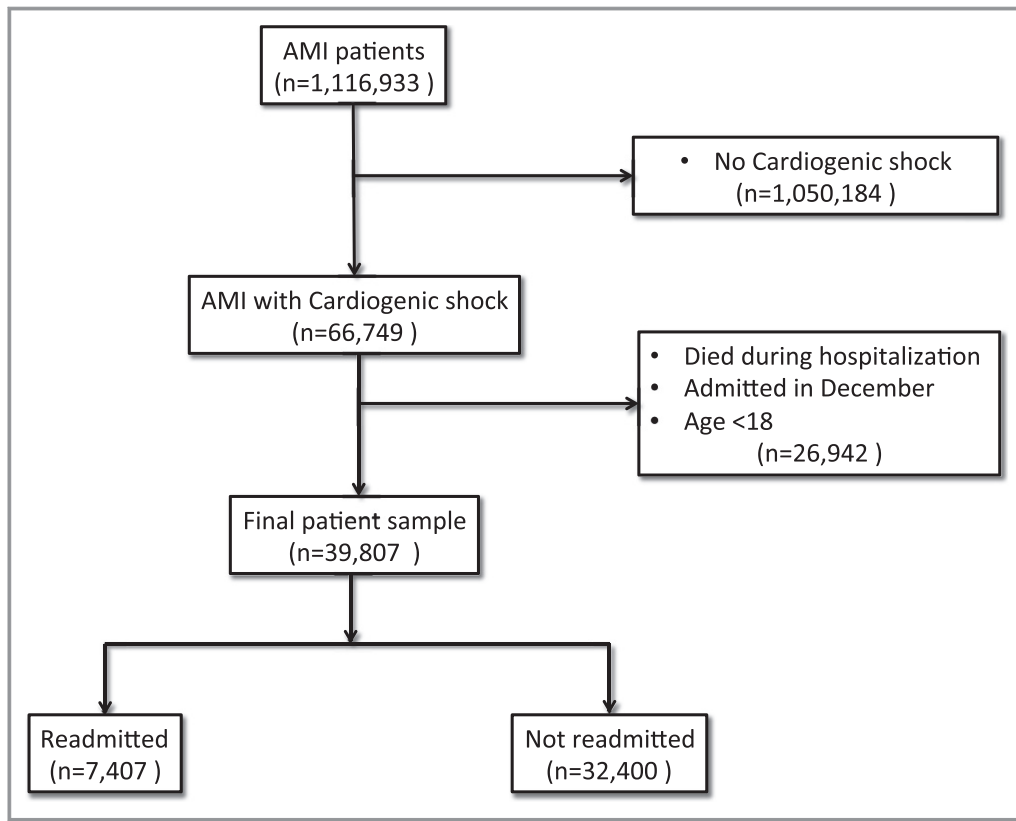
Figure 1. Study flow chart diagram. AMI indicates acute myocardial infarction.

between hospital discharge after index hospitalization and the initial day of hospital readmission. The primary diagnosis for each readmission record was reviewed individually (independently by 2 authors masked to each other's findings, and reconciliation of the differences between both authors was done by a third author) and were further categorized into cardiac and noncardiac related. Cardiac causes included heart failure, reinfarction (ie, STEMI or NSTEMI), arrhythmias, conduction disorders, chest pain, hypertension, hypotension, syncope, pericarditis, coronary artery disease, and others. Noncardiac causes included respiratory, infectious, bleeding, renal, gastrointestinal, trauma, hematological, neoplasms, endocrine/metabolic, neurological (including transient ischemic attack/stroke), psychiatric, and others. The median length of stay and median hospital costs were also calculated.

Statistical Analysis

Categorical variables are expressed using frequencies and compared using Pearson chi-square test. Nonskewed continuous variables are expressed using mean±SD and compared using Student t test. Skewed continuous variables are expressed using median with 25th to 75th percentile range and compared using the Wilcoxon rank-sum test. Weighted

estimates were calculated by survey analysis methods (svy command in Stata) using the variable "DISCWT" provided by NRD as a weight variable and "HOSP_NRD" as the clustering variable as recommended by the AHRQ. This was performed to ensure accurate national representative estimates of the US population of hospitalized patients. The HOSP_NRD variable is a HCUP hospital identifier specifically created for the NRD. The purpose of this variable is to accurately identify inpatient records that are associated with the same hospital. HOSP_NRD does not link to other HCUP databases or to external databases.[10] Independent predictors of 30-day readmission were identified with a 2-level hierarchical multivariable logistic regression model (multilevel mixed-effects logistic regression model "melogit" in Stata) to account for in-between hospital variations and hospital clustering effect using the hospital cluster variable "HOSP_NRD" as a second-level variable. A total of 63 covariates were included in the first-level model: they included baseline demographics, chronic comorbidities, hospital characteristics, in-hospital procedures (eg, percutaneous coronary intervention), and in-hospital complications. Statistical analyses were conducted using Stata software version 14 (StataCorp). A 2-sided value of $P<0.05$ was set for statistical significance. Categorical variables are presented as frequencies and percentages and continuous

Table 1. *ICD-9* Codes of All Covariates Used in the Study

Variable	*ICD-9* Code
Family history of CAD	V17.3
Prior MI	412
Prior PCI	V45.82
Prior CABG	V45.81
Prior stroke/TIA	V12.54
Carotid artery disease	433.10
Smoking history	V15.82, 305.1
Dyslipidemia	53
Acute renal failure	584.5 to 584.9
Acute ischemic stroke	433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91, 435.x, 436
Intracranial hemorrhage	430, 431, 432.x
Gastrointestinal bleeding	578.0, 578.1, 578.9
Pneumonia	486, 481, 482.8, 482.3
DVT/PE	451.1, 451.2, 451.81, 451.9, 453.1, 453.2, 453.8, 453.9, 415.1
Sepsis	995.91, 996.64, 038x, 995.92, 998.59, and 999.3
Atrial fibrillation	427.31
Ventricular tachycardia	427.1
Ventricular fibrillation	427.41
PCI	00.66, 36.01, 36.06, 36.07, and 36.09
Intubation/mechanical ventilation	96.01 to 96.05, 96.7x
Intra-aortic balloon pump placement	37.61
Short-term ventricular assist device	37.68, 37.60, 37.62, or 37.65
Long-term ventricular assist device placement	37.66, 37.52
Pacemaker/defibrillator placement	37.80–83, 00.51, 00.50, 37.94, 37.96

Other variables not reported were collected using Elixhauser Comorbidity Software (https://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp). CABG indicates coronary artery bypass grafting; CAD, coronary artery disease; DVT/PE, deep venous thrombosis/pulmonary embolization; *ICD-9*, *International Classification of Diseases, Ninth Edition*; MI, myocardial infarction; PCI, percutaneous coronary intervention; TIA, transient ischemic attack.

variables as mean±SD or median and 25th to 75th percentile range.

Results

Among 1 116 933 hospitalizations with a primary diagnosis of AMI in the NRD database years 2013 and 2014 (335 548 with STEMI, and 781 385 with NSTEMI), 66 749 (6.0%) developed cardiogenic shock. Of those, 39 807 (59.6%) were discharged alive from January until November, representing the final cohort included in our analysis (Figure 1).

Prevalence and Predictors of Readmission

Of 39 807 hospitalizations with AMI and cardiogenic shock, a total of 7407 (18.6%) were readmitted after 30 days, with a median time for readmission of 10 days (4–18 days) after discharge (Figure 2). Meanwhile, 131 043 AMI hospitalizations without cardiogenic shock were readmitted of 921 004 index hospitalizations discharged alive at the same period (14.2% versus 18.6%, $P<0.0001$). Table 2 summarizes the baseline characteristics for the cohort. Table 3 summarizes the hospital characteristics and Table 4 reports the in-hospital procedures and complications in each group.

Multivariate analysis identified the following patient characteristics to be associated with 30-day readmission: female sex (odds ratio [OR], 1.12; 95% confidence interval [CI], 1.02–1.23, $P=0.022$), anemia (OR, 1.15; 95% CI, 1.04–1.29 [$P=0.009$]), chronic obstructive pulmonary disease (OR, 1.16; 95% CI, 1.05–1.29 [$P=0.003$]), diabetes mellitus without (OR, 1.15; 95% CI, 1.05–1.26 [$P=0.004$]) or with (OR, 1.44; 95% CI, 1.24–1.68 [$P<0.0001$]) complications, peripheral vascular disease (OR, 1.29; 95% CI, 1.14–1.45 [$P<0.0001$]), and chronic renal failure (OR, 1.25; 95% CI, 1.11–1.40 [$P<0.0001$]). The clinical presentation of STEMI versus NSTEMI was a predictor of marginal significance, suggesting a lower incidence of 30-day readmission among patients with STEMI (OR, 0.91; 95% CI, 0.82–1.00 [$P=0.042$]). Placement of a long-term ventricular assist device or intra-aortic balloon pump was associated with higher 30-day readmission rates (Table 4). Among the in-hospital complications evaluated, ventricular tachycardia and atrial fibrillation were associated with higher readmission rates (Table 4). Meanwhile, high median home income (OR, 0.84; 95% CI, 0.73–0.96 [$P=0.010$]) and non-Medicare/Medicaid payers and hospitals located in low-population areas were all associated with lower 30-day readmissions (Table 5).

Reasons for 30-Day Readmissions

The most frequent reasons for readmission were cardiac (51.5%), infectious (14.8%), and bleeding (5.3%) (Figure 3). The most frequent cardiac reason for readmission was heart failure (39%) followed by reinfarction (14.4%) and coronary artery disease (13.3%) (Figure 4). The noncardiac-related causes (48.5%) included infections (14.8%) (Figure 5), bleeding (5.3%) (gastrointestinal bleeding contributed to 58% of all bleeding causes) (Figure 6), respiratory (4.9%), iatrogenic (3.7%) (device-related complications contributed to 60.3% of all iatrogenic causes), renal (2.8%), gastrointestinal (2.7%), metabolic/endocrine (2.5%), neurological (2.4%), vascular
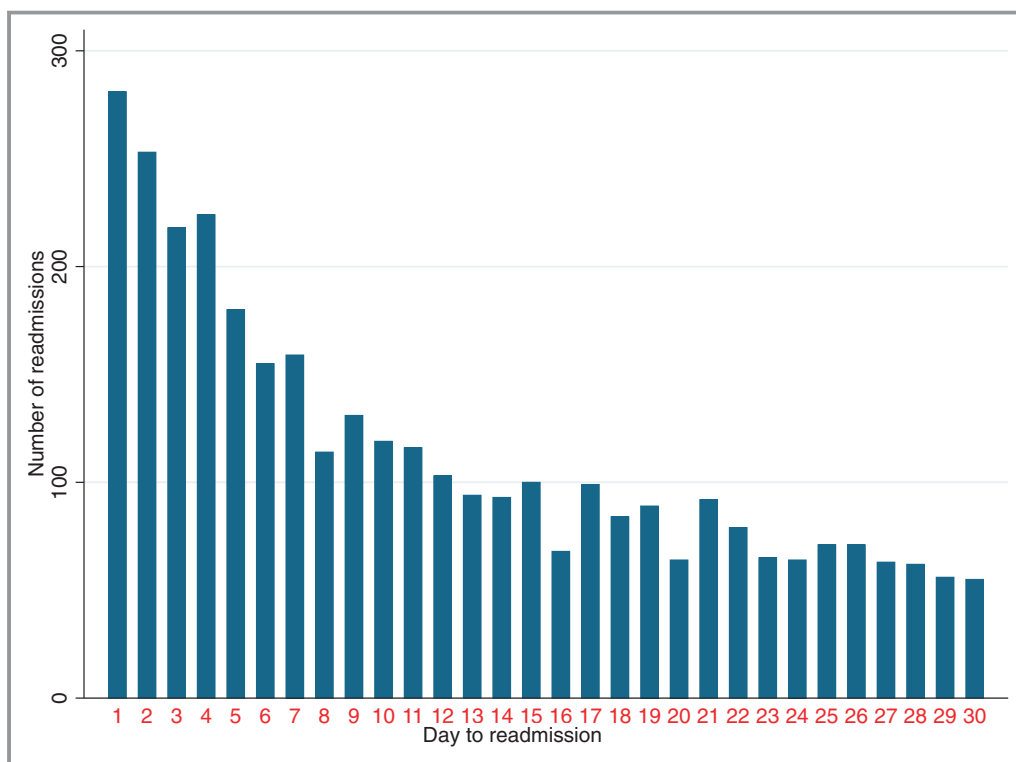
Figure 2. Frequencies of readmission according to the number of days after discharge in the acute myocardial infarction with cardiogenic shock hospitalization cohort.

(1.1%), and others (Figure 3). Among those readmitted within 30 days, the in-hospital mortality rate was 7.6%.

Median Length of Stay and Hospital Costs of 30-Day Readmissions

The median length of stay in the readmitted cohort was 4 days (2–8 days) with total hospital costs of $129 000 000 US dollars (95% CI, $117 000 000–$141 000 000). The median hospital cost per one 30-day readmission was $9473 US dollars ($5037–20 199).

Discussion

In this observational analysis of a large, real-world cohort of hospitalizations with AMI complicated by cardiogenic shock, we identified 30-day readmission in almost 1 of 5 hospital-izations. The median time to readmission was 10 days. The risk of readmission at 30 days was marginally lower among patients with STEMI compared with NSTEMI. Female sex, low socioeconomic status, Medicaid insurance, mechanical sup-port device placement (ie, intra-aortic balloon pump and long-term ventricular support devices), and atrial fibrillation, as well as ventricular tachycardia were all predictors of readmission at 30 days. To the best of our knowledge, this is the first study to evaluate the causes of readmission in patients

hospitalized with AMI complicated by cardiogenic shock. In this cohort, cardiac-related causes accounted for a majority of the readmissions, with heart failure and reinfarction being the most frequent reasons. The most frequent causes for noncardiac-related admissions included infections, bleeding, and respiratory causes.

In recent years, the number of patients with AMI surviving cardiogenic shock to be discharged from the hospital has been increasing. However, this subset of patients represents a cohort that is more vulnerable for early readmissions. This is important for patients, payers, healthcare delivery systems, and advocacy groups to increase support for research in this area. Thirty-day readmission has been used as a performance metric by the Centers for Medicare & Medicaid Services to assess the quality of hospital care and to penalize hospitals with higher-than-expected readmission rates for certain conditions such as AMI, heart failure, and pneumonia. In our study, the 30-day readmission rate for AMI complicated with cardiogenic shock was 18.6%, which is slightly lower than hospitalizations with a principal diagnosis of congestive heart failure (23.5%) or chronic obstructive pulmonary disease (20.0%); however, it is considerably higher than those with a principal diagnosis of AMI (without cardiogenic shock) (14.2%), pneumonia (15.5%) or any other cause combined (12.2%).[11] Several studies in the revascularization era indicate that post-discharge AMI outcomes are worse in the setting of

Table 2. Baseline Characteristics of the Study Cohort Stratified by Readmission Status

Variable	Overall, %	No Readmission, %	Readmission, %	P Value
Patients, No.	100 (39 807)	81.4 (32 400)	18.6 (7407)	
Primary diagnosis				
STEMI	56.9	58.1	51.7	<0.0001
Patient demographics				
Age, mean (95% CI), y	66.5 (66.3–66.8)	66.2 (65.9–66.5)	67.8 (67.3–68.4)	<0.0001
Female	33.2	32.4	37.0	<0.0001
Weekend admission	26.8	26.7	27.4	0.458
Family history of CAD	15.4	16.3	11.8	<0.0001
Prior MI	17.8	18.1	16.7	0.078
Prior PCI	20.2	20.5	18.7	0.028
Prior CABG	13.6	13.9	12.3	0.022
Prior stroke	13.6	14.0	11.8	0.002
Carotid artery disease	11.7	12.1	9.7	<0.0001
Smoking history	42.4	43.4	37.9	<0.0001
Dyslipidemia	9.6	10.1	7.5	<0.0001
Median home income				0.089
1st to 25th percentile	27.6	27.2	29.6	
26th to 50th percentile	28.5	28.7	27.6	
51st to 75th percentile	24.6	24.7	24.2	
75th to 100th percentile	19.3	19.4	18.6	
Expected payer				<0.0001
Medicare	57.6	55.8	65.1	
Medicaid	8.6	8.4	9.5	
Private	24.3	25.8	18.0	
Self	5.4	5.7	4.2	
No charge	0.7	0.7	0.6	
Other	3.4	3.6	2.5	
Chronic comorbidities				
AIDS	0.1	0.1	0.1	0.831
Alcohol abuse	4.9	5.0	4.4	0.207
Anemia	22.7	21.4	28.3	<0.0001
Collagen and rheumatologic disease	2.4	2.2	3.0	0.033
Chronic blood loss	1.2	1.1	1.5	0.157
CHF	4.2	4.1	4.9	0.068
COPD	23.1	22.3	26.2	<0.0001
Coagulopathy	16.7	16.4	18.1	0.018
Depression	7.1	6.9	7.9	0.043
DM uncomplicated	30.2	29.7	32.6	<0.0001
DM complicated	8.6	7.6	12.7	<0.0001
Drug abuse	3.0	3.0	3.4	0.296
Hypertension	64.9	64.5	66.7	0.025
Hypothyroidism	9.9	9.6	11.2	0.017

Table 2. Continued

Variable	Overall, %	No Readmission, %	Readmission, %	P Value
Chronic liver disease	1.8	1.7	2.2	0.064
Lymphoma	0.6	0.6	0.7	0.361
Fluid and electrolytes disturbances	46.1	45.0	50.7	<0.0001
Metastatic cancer	0.8	0.7	1.2	0.007
Neurological disorders	7.1	7.2	6.6	0.275
Obesity	16.7	16.8	16.5	0.690
Paralysis	2.5	2.5	2.7	0.491
Peripheral vascular disease	14.8	13.7	19.5	<0.0001
Psychosis	3.0	2.7	4.0	0.001
Pulmonary circulation disorders	0.7	0.6	0.8	0.363
Chronic renal failure	22.7	21.0	30.1	<0.0001
Peptic ulcer disease	…	…	…	
Valvular heart disease	1.4	1.3	1.5	0.340
Weight loss	8.5	8.1	10.1	0.001

CABG indicates coronary artery bypass grafting; CAD, coronary artery disease; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; MI, myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

prior cardiogenic shock. However, this effect appeared to be time-dependent and is clustered early on.[7,12] In fact, the mortality rates of these patients are comparable to those with AMI without cardiogenic shock at 5 years.[13] In this study, the median time to readmission was 10 days (range 8–14 days), which is consistent with Medicare data that found the median time of readmission after AMI was 10 days.[14] Therefore, improved prevention and interventions early in the course of

Table 3. Hospital Characteristics of the Cohort Stratified by Readmission Status

Variable	Overall, %	No Readmission, %	Readmission, %	P Value
Peri-hospital population size				<0.0001
Central metropolitan >1 million	23.8	23.0	27.3	
Fringe metropolitan >1 million	24.7	24.5	25.8	
Metropolitan 250 000 to 999 999 population	20.5	20.8	19.2	
Metropolitan 50 000 to 249 999 population	10.3	10.3	10.2	
Micropolitan	11.5	12.0	9.7	
Nonmetropolitan or micropolitan	9.1	9.4	7.8	
Hospital bed size				0.11
Small bed size	6.9	7.1	6.3	
Medium bed size	21.7	22.0	20.7	
Large bed size	71.4	71.0	73.0	
Hospital ownership				0.03
Government nonfederal	10.0	9.8	11.1	
Private nonprofit	76.3	76.7	74.8	
Private investment	13.6	13.5	14.1	
Hospital teaching status				0.61
Urban nonteaching	31.9	31.8	32.3	
Urban teaching	63.2	63.2	63.2	
Rural nonteaching	4.9	5.0	4.5	

Table 4. In-Hospital Procedures and Complications of the Cohort Stratified by Readmission Status

Variable	Overall, %	No Readmission, %	Readmission, %	P Value
In-hospital procedures				
PCI	59.3	60.0	56.3	0.0002
Long-term VAD	0.5	0.4	0.7	0.008
Short-term VAD	3.4	3.4	3.6	0.543
IABP	39.6	39.1	41.8	0.009
Pacemaker/defibrillator	3.9	3.9	4.0	0.783
Intubation/mechanical ventilation	34.8	34.2	37.6	0.001
In-hospital complications				
Acute renal failure	45.9	45.1	49.5	<0.0001
Pneumonia	20.9	21.0	20.5	0.565
GIB	13.4	13.9	11.3	<0.0001
ICH	10.0	10.6	7.7	<0.0001
Acute ischemic stroke/TIA	12.7	13.1	11.0	0.001
DVT/PE	9.8	10.3	7.6	<0.0001
Sepsis	17.9	17.9	17.7	0.806
Atrial fibrillation	33.3	32.9	34.8	0.040
Ventricular tachycardia	25.5	25.7	24.8	0.338
Ventricular fibrillation	23.3	24.0	20.1	<0.0001

DVT/PE indicates deep venous thrombosis/pulmonary embolism; GIB, gastrointestinal bleeding; IABP, intra-aortic balloon pump; ICH, intracranial hemorrhage; PCI, percutaneous coronary intervention; TIA, transient ischemic attack; VAD, ventricular assist device.

management are likely important to improve outcomes in the short-term period in these patients. Besides the morbidity and health resources consumption resulting from readmissions, our analysis suggests that readmissions after an AMI with cardiogenic shock are associated with a significant economic burden (ie, total cost ≈$65 million US dollars per year).

We identified certain patient-related characteristics associated with higher risk of 30-day readmission such as female sex, diabetes mellitus, anemia peripheral vascular disease, and chronic renal failure, as well as presentation with NSTEMI. These characteristics are consistent with other studies that have evaluated 30-day readmission after AMI without cardiogenic shock. In a population-based analysis of 3010 patients with AMI, diabetes mellitus, chronic obstructive pulmonary disease, and anemia were predictors of 30-day readmissions, but the type of AMI was not.[15] Thus, a multidisciplinary team approach (including a cardiologist, general internist, endocrinologist, nephrologist, and hematologist) might be a valid option for managing patients with AMI and cardiogenic shock. This approach could ultimately help in preventing unplanned noncardiac readmissions at the early post-discharge period.

A previous analysis of the NRD evaluated readmission rates after AMI complicated by cardiogenic shock, stratified by sex, suggested that women have a higher risk of 30-day readmission after AMI versus men.[16] Unfortunately, it was not possible to assess other factors suggested to correlate with 30-day readmission after AMI in general, such as complications of angiography/revascularization,[15] as well as medication adherence[17] and health literacy,[18] in our study since these variables are not available in the NRD. Potentially arranging for early post-discharge physician follow-up for those who are at increased risk of readmission could help mitigate this risk. Data from the Medicare population have suggested that earlier post-discharge follow-up after NSTEMI is linked with lower risk of 30-day readmissions.[19] We also identified that certain hospital-related characteristics, such as those seen in low-population areas, were linked to lower 30-day readmission after AMI and cardiogenic shock. An analysis of the Medicare data shows some regional variations across hospitals in 30-day readmission rates after AMI,[20] which suggests that further improvements are also needed at the hospital levels.

Study Strengths and Limitations

The strength of this study includes the large number of hospitalizations that are included from real-world data. By using multivariate hierarchal logistic regression, we attempted

Table 5. Predictors of 30-Day Readmission Following AMI and Cardiogenic Shock

Variable	Odds Ratio	95% CI		P Value
Primary diagnosis				
STEMI	0.91	0.82	1.00	0.042
Patient demographics				
Age >80 y	0.97	0.86	1.09	0.589
Female sex	1.12	1.02	1.23	0.022
Weekend admission	1.04	0.95	1.15	0.393
Family history of CAD	0.82	0.67	1.00	0.053
Prior MI	1.06	0.90	1.24	0.493
Prior PCI	1.03	0.89	1.19	0.733
Prior CABG	1.10	0.90	1.33	0.346
Prior stroke/TIA	0.93	0.75	1.14	0.463
Carotid artery disease	0.92	0.67	1.26	0.597
Smoking history	0.90	0.81	0.99	0.031
Dyslipidemia	2.40	0.49	11.69	0.279
Median home income (reference: 1st to 25th percentile)				
26th to 50th percentile	0.89	0.80	1.00	0.044
51st to 75th percentile	0.88	0.78	1.01	0.066
75th to 100th percentile	0.84	0.73	0.96	0.010
Expected payer (reference: Medicare)				
Medicaid	0.99	0.85	1.16	0.920
Private	0.70	0.62	0.79	<0.0001
Self	0.76	0.61	0.93	0.009
No charge	0.94	0.58	1.52	0.797
Other	0.69	0.54	0.88	0.004
Chronic comorbidities				
AIDS	1.06	0.40	2.81	0.911
Alcohol abuse	0.91	0.74	1.13	0.404
Anemia	1.15	1.04	1.29	0.009
Collagen vascular disease	1.31	0.97	1.76	0.074
Chronic blood loss	1.12	0.77	1.62	0.545
CHF	0.95	0.76	1.18	0.635
Coagulopathy	0.95	0.85	1.07	0.385
COPD	1.16	1.05	1.29	0.003
Depression	1.09	0.93	1.27	0.307
DM without complications	1.15	1.05	1.26	0.004
DM with complications	1.44	1.24	1.68	<0.0001
Drug abuse	1.17	0.90	1.53	0.234
Hypertension	0.96	0.87	1.06	0.411
Hypothyroidism	1.05	0.92	1.20	0.456
Chronic liver disease	1.18	0.92	1.53	0.196
Lymphoma	1.07	0.64	1.77	0.806

Table 5. Continued

Variable	Odds Ratio	95% CI		P Value
Fluid and electrolytes disturbance	1.07	0.98	1.17	0.125
Metastatic cancer	1.62	1.06	2.46	0.024
Neurological disorders	0.82	0.69	0.98	0.026
Obesity	0.90	0.79	1.02	0.091
Paraplegia	0.86	0.65	1.14	0.290
PVD	1.29	1.14	1.45	<0.0001
Psychosis	1.38	1.07	1.77	0.013
Pulmonary vascular disease	1.05	0.58	1.88	0.873
Chronic renal failure	1.25	1.11	1.40	<0.0001
Tumors	1.25	0.91	1.71	0.176
Peptic ulcer	3.34	0.49	22.67	0.216
Weight loss	1.02	0.87	1.18	0.838
Valvular heart disease	0.91	0.62	1.35	0.653
Procedures				
PCI	1.03	0.94	1.12	0.590
Long-term VAD	1.78	1.16	2.71	0.008
Short-term VAD	1.13	0.90	1.42	0.291
IABP	1.17	1.06	1.29	0.001
Pacemaker/defibrillator placement	0.91	0.73	1.13	0.405
Intubation/mechanical ventilation	1.05	0.94	1.16	0.390
In-hospital complications				
Acute renal failure	1.04	0.94	1.14	0.467
Acute ischemic stroke/TIA	1.12	0.87	1.44	0.386
ICH	0.57	0.24	1.33	0.193
GIB	0.87	0.70	1.07	0.190
Pneumonia	1.02	0.89	1.17	0.761
DVT/PE	0.55	0.17	1.75	0.310
Sepsis	1.16	1.00	1.35	0.051
Atrial fibrillation	1.12	1.01	1.23	0.024
Ventricular tachycardia	1.16	1.03	1.31	0.017
Ventricular fibrillation	0.98	0.85	1.12	0.748
Hospital characteristics				
Population size (reference: large metropolitan >1 million population)				
Fringe metropolitan >1 million	0.95	0.84	1.07	0.408
Metropolitan 250 000–999 999 population	0.83	0.74	0.94	0.004
Metropolitan 50 000–249 999 population	0.91	0.78	1.05	0.190
Micropolitan	0.67	0.57	0.79	<0.0001
Nonmetropolitan or micropolitan	0.66	0.54	0.80	<0.0001
Hospital bed size (reference is small bed size)				
Medium bed size	1.06	0.87	1.30	0.544
Large bed size	1.09	0.91	1.31	0.352

Table 5. Continued

Variable	Odds Ratio	95% CI		P Value
Hospital ownership (reference is government hospitals)				
Private nonprofit	0.83	0.73	0.94	0.004
Private investment	0.87	0.74	1.03	0.104
Hospital teaching status (reference is urban nonteaching)				
Urban teaching	0.97	0.88	1.07	0.514
Rural nonteaching	1.07	0.82	1.40	0.628

AMI indicates acute myocardial infarction; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; DVT/PE, deep venous thrombosis/pulmonary embolization; GIB, gastrointestinal bleeding; IABP, intra-aortic balloon pump; ICH, intracranial hemorrhage; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; STEMI, ST-segment elevation myocardial infarction; TIA, transient ischemic attack; VAD, ventricular assist device.

to account for any potential clustering effect between the hospitals. However, our study has several limitations. First, this is an observational, nonrandomized analysis. Although we adjusted for multiple confounding variables, the risk of unmeasured confounding could not be completely excluded. Second, the NRD lacks data regarding the access site (radial versus femoral), as well as the stent type, and important medications (ie, anticoagulants and antiplatelet therapy), which have been implicated in affecting the outcomes of patients with cardiogenic shock. Further, data regarding complete revascularization that are known to impact the outcomes in AMI and shock were not available.[21,22] Third, readmissions cannot be tracked across different states or across calendar years. Thus, our numbers are likely to represent underestimates. Fourth, the NRD represents an administrative database, thus it is subject to known limitations of such data sources (eg, coding errors and bias). Last, given the large sample size of the current study and the large number of variables included in the adjustment model, the statistical significance of some of the predictor variables with CIs approaching 1 could be caused by chance (ie, type I error). Thus, we strongly believe that the statistical significance of such predictors should be balanced with the magnitude of effect, the quality of the study, and findings shown in other studies.
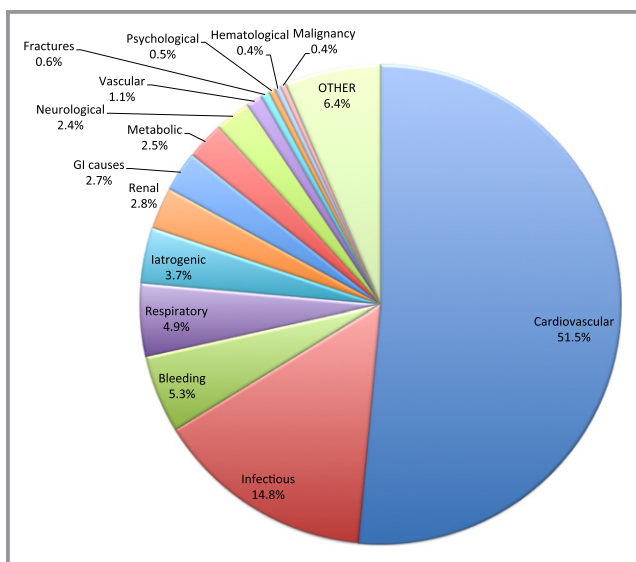

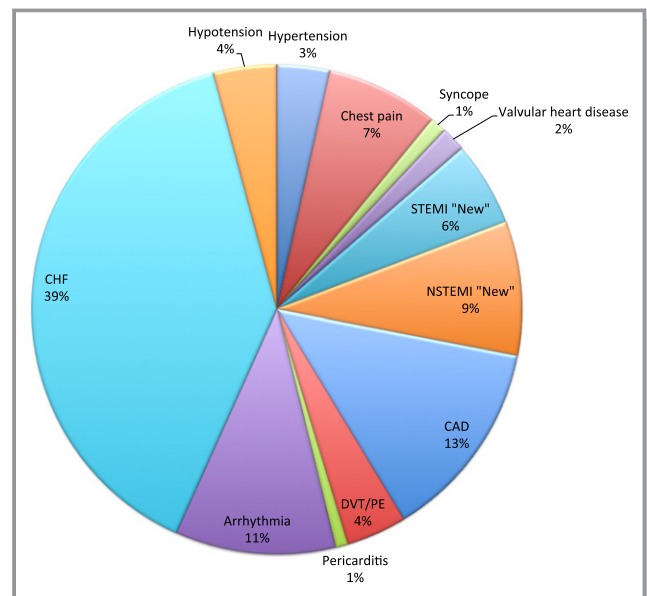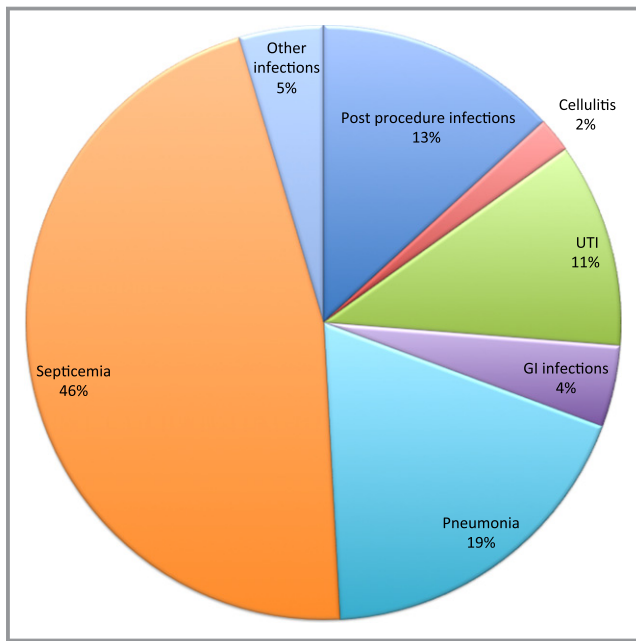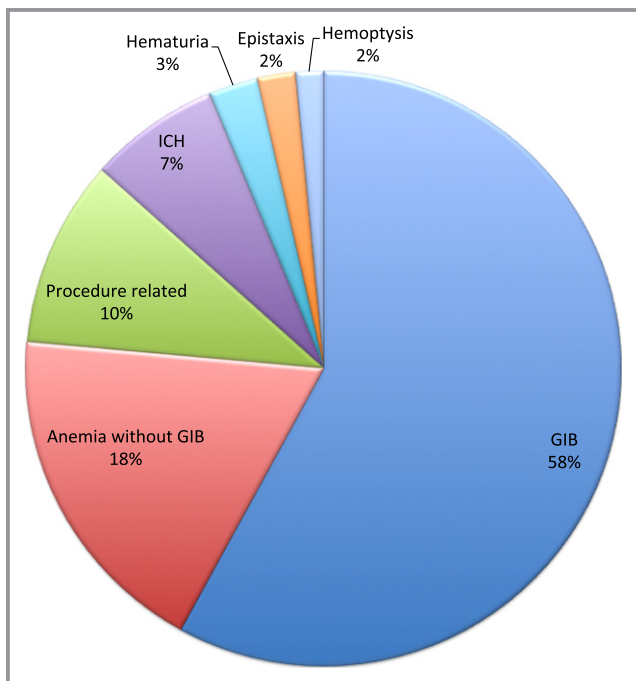**Figure 3.** Overall causes of 30-day readmission. GI indicates gastrointestinal.

Figure 4. Cardiac causes of 30-day readmission. CAD indicates coronary artery disease; CHF, congestive heart failure; DVT/PE, deep venous thrombosis/pulmonary embolism; NSTEMI, non–ST-segment elevation myocardial infarction; STEMI, ST-segment elevation myocardial infarction (Percentage is out of all cardiac 30-day readmissions).

Figure 5. Infectious causes of 30-day readmission. GI indicates gastrointestinal; UTI, urinary tract infection (Percentage is out of all infectious causes of 30-day readmissions).

Conclusions

AMI complicated with cardiogenic shock is associated with high rates of readmissions at 30 days, mainly attributable to

Figure 6. Bleeding causes of 30-day readmission. GIB indicates gastrointestinal bleeding; ICH, intracranial hemorrhage (Percentage is out of all bleeding causes of 30-day readmissions).

cardiac reasons such as heart failure and new AMI. The risk of readmission is associated with certain baseline patient/hospital characteristics and in-hospital procedures/complications.

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Disclosures

None.

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