Causes and Predictors of 30-Day Readmission in Patients With Acute Myocardial Infarction and Cardiogenic Shock.

Mahek Shah MD
Lehigh Valley Health Network, Mahek.Shah@lvhn.org

Shantanu Patil

Brijesh Patel MD
Lehigh Valley Health Network, brijesh.patel@lvhn.org

Manyoo Agarwal

Carlos D Davila

See next page for additional authors

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ORIGINAL ARTICLE

Causes and Predictors of 30-Day Readmission in Patients With Acute Myocardial Infarction and Cardiogenic Shock

Mahek Shah, MD*
Shantanu Patil, MD*
Brijesh Patel, DO
Manyoo Agarwal, MD
Carlos D. Davila, MD
Lohit Garg, MD
Sahil Agrawal, MD
Navin K. Kapur, MD
Ulrich P. Jorde, MD

BACKGROUND: Acute myocardial infarction (AMI) occurs as a result of irreversible damage to cardiac myocytes secondary to lack of blood supply. Cardiogenic shock complicating AMI has significant associated morbidity and mortality, and data on postdischarge outcomes are limited.

METHODS AND RESULTS: We derived the study cohort of patients with AMI and cardiogenic shock from the 2013 to 2014 Healthcare Cost and Utilization Project National Readmission Database. Incidence, predictors, and causes of 30-day readmissions were analyzed. From 43 212 index admissions for AMI with cardiogenic shock, 26 016 (60.2%) survived to discharge and 5277 (20.2% of survivors) patients were readmitted within 30 days. More than 50% of these readmissions occurred within first 10 days. Cardiac causes accounted for 42% of 30-day readmissions (heart failure 20.6%; acute coronary syndrome 11.6%). Among noncardiac causes, respiratory (11.4%), infectious (9.4%), medical or surgical care complications (6.3%), gastrointestinal/hepatobiliary (6.5%), and renal causes (4.8%) were most common. Length of stay ≥8 days (odds ratio [OR], 2.04; 95% confidence interval [CI], 1.70–2.44; $P<0.01$), acute deep venous thrombosis (OR, 1.26; 95% CI, 1.08–1.48; $P<0.01$), liver disease (OR, 1.25; 95% CI, 1.03–1.50; $P=0.02$), systemic thromboembolism (OR, 1.21; 95% CI, 1.02–1.44; $P=0.02$), peripheral vascular disease (OR, 1.16; 95% CI, 1.07–1.27; $P<0.01$), diabetes mellitus (OR, 1.16; 95% CI, 1.08–1.24; $P<0.01$), long-term ventricular assist device implantation (OR, 1.77; 95% CI, 1.23–2.55; $P<0.01$), intraaortic balloon pump use (OR, 1.10; 95% CI, 1.02–1.18; $P<0.01$), performance of coronary artery bypass grafting (OR, 0.85; 95% CI, 0.77–0.93; $P<0.01$), private insurance (OR, 0.72; 95% CI, 0.64–0.80; $P<0.01$), and discharge to home (OR, 0.85; 95% CI, 0.73–0.98; $P=0.03$) were among the independent predictors of 30-day readmission.

CONCLUSIONS: In-hospital mortality and 30-day readmission in cardiogenic shock complicating AMI are significantly elevated. Patients are readmitted mainly for noncardiac causes. Identification of high-risk factors may guide interventions to improve outcomes within this population.

*Drs Shah and Patil contributed equally to this work.

Key Words: heart failure ■ mortality ■ myocardial infarction ■ readmission ■ shock, cardiogenic

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WHAT IS NEW?

- Cardiogenic shock complicating acute myocardial infarction is associated with a significant mortality burden during initial admission. Survivors of cardiogenic shock remain at a markedly elevated risk for early readmission and hospital mortality during readmission.

WHAT ARE THE CLINICAL IMPLICATIONS?

- Among patients admitted with cardiogenic shock complicating acute myocardial infarction, 40% patients died during the index hospitalization and an additional 10% of the survivors died during rehospitalization within 30 days.
- One out of every 5 survivors was readmitted within 30 days of discharge, for predominantly noncardiovascular causes. Heart failure was the most common cardiovascular reason for 30-day readmission.
- Female sex, length of stay >4 days, underlying diabetes mellitus, chronic lung or kidney disease, and use of balloon pump or permanent ventricular assist device implantation predicted higher 30-day readmission.
- The annual estimated hospitalization-related cost burden for index admission and 30-day readmission among patients with cardiogenic shock complicating acute myocardial infarction was >$2.7 billion.

Frequent hospital readmission has an adverse effect on patients, putting them at risk for hospital-acquired infections or complications, and increases the cost burden for both public and private payers. Under the Hospital Readmissions Reduction Program, the centers for Medicare and Medicaid Services considers 30-day hospital readmission as a measure of patient care quality and penalizes hospitals for high readmission rates.[1,2] More than three fourth of the hospitals were subject to the Hospital Readmissions Reduction Program penalty during the fiscal year of 2016. Roughly 18% of all Medicare patients are readmitted within 30 days, amounting to an annual cost of $15 billion. Considering the negative consequences of readmission, several hospitals across the country have implemented measures directed towards reduction in preventable complications from hospitalization, enhanced quality of patient discharge, better transition of care post-hospitalization, and improved communication and coordination of care with other healthcare providers to reduce readmission rates.[3–5] Recent analyses indicate that continued efforts in this direction among conditions with a high rate of readmission, such as acute heart failure or acute myocardial infarction (AMI), have shown potential in reducing unplanned readmissions and associated expenditures.[4,6]

Cardiogenic shock (CS) is a devastating complication of AMI and is associated with significant mortality and morbidity.[7] The incidence of CS from AMI ranges from 5% to 10%.[8,9] Recent advances in reperfusion strategies, pharmacological breakthroughs, and mechanical innovations have significantly decreased inpatient mortality from CS in the past decade.[9,10] With improving trends in mortality associated with CS, a better understanding about prognosis of survivors is warranted. A recent study by Shah et al[11] highlighted a high incidence of 1-year mortality after discharge in this vulnerable population. In this large real-world nationwide cohort, we aimed to explore the incidence, predictors, causes, and cost impact for 30-day readmission after admission for CS complicating AMI.

METHODS

The data, analytic methods, and study materials will be made available to other researchers for purposes of reproducing the results or replicating the procedure. The study cohort was derived from Healthcare Cost and Utilization Project National Readmission Database (NRD) of 2013 and 2014, sponsored by the Agency for Healthcare Research and Quality. Because the NRD database is publicly available and contains deidentified patient information, the study was labeled as exempt from institutional board review. NRD represents 49.1% of total US hospitalizations. NRD is one of the largest publicly available all-payer inpatient database in the United States, including data on ≈28 million discharges per year, estimating >50 million discharges from 21 states with reliable, verified linkage numbers. Patients can be tracked using these linkage numbers for readmission within the same calendar year. The time to readmission in days can subsequently be calculated using a timing variable assigned for each admission within the database and adjusting for the length of stay (LOS) from the antecedent hospitalization. Additional details on the NRD database are available online.[12]

We queried the NRD database using *International Classification of Diseases*, *Ninth Revision*, Clinical Modification (*ICD-9* CM) diagnosis codes to identify patients with a primary admission for AMI (*ICD-9* CM code: 410x, 411.1) who had an additional diagnosis of CS (*ICD-9* CM code: 785.51). Only the initial admission for calendar year per patient was included for analysis as an index admission. We excluded patients with age ≤16 years and those missing data for age, sex, or mortality. We also excluded index admissions from December for both study years, as 30-day follow-up information for these patients was incomplete.

The primary outcome was 30-day readmission. Patients who were readmitted within 30 days postdischarge from index admission were further evaluated. Readmission causes were identified by using *ICD-9* CM codes in the primary diagnosis field. We identified and combined the *ICD-9* CM codes with similar diagnoses to make clinically important groups. Within the groups with primary admissions for AMI with CS and 30-day readmissions, we used *ICD-9* CM codes to define additional variables and comorbidities (Table I in the Data Supplement).

NRD variables were used to identify patients' demographic characteristics, including age; sex; hospital characteristics such as bed size and teaching status; and additional patient-specific characteristics, primary payer information, admission

type, admission day, and discharge disposition. CM variables identified different comorbidities by using *ICD-9* CM diagnoses and the diagnosis-related group in effect on the discharge data. These comorbidities are not directly related to the principal diagnosis or the main reason for admission and are likely to have originated before the hospital stay. Severity of comorbid conditions was defined using Deyo modification of Charlson comorbidity index (CCI), which contains 17 comorbid conditions with differential weights, and the Elixhauser comorbidity index, which is a sum of the 29 Elixhauser comorbidity variables within database. The Charlson comorbidity score ranges from 0 to 33, with higher scores corresponding to greater burden of comorbid diseases.[13] National cost estimates were calculated after weighting of the study data set using sampling weights provided within database.

Statistics

All analyses were performed using the IBM SPSS Statistics for Windows, version 23.0 (Armonk, NY) software. Categorical data were expressed as percentages and continuous data as mean±1 SD. Differences between categorical variables and continuous variable were tested using the Pearson χ^2 test and Student *t* test, respectively. A multivariable mixed-effect logistic regression model was created to assess which variables predicted 30-day readmission with hospital identity as random effect. The multivariate models for readmission included hospital-level variables like bed size and location/teaching status; patient-level variables like age groups, sex, CCI categories, admission type, admission day, and primary payer; income quartile; LOS of index admission; calendar year; comorbidities; and disposition post-index admission as shown in Table III in the Data Supplement. Patients who died at the end of index admission were excluded from the regression model.

RESULTS

Baseline Characteristics

A total of 43 212 admissions of CS complicating AMI were included in the study and comprised the index admission patient cohort. Out of these, 26 016 (60.2%) survived their index hospitalization with an in-hospital mortality rate of 39.8%. Mean age, length, and cost of stay were 69.3 years, 11.0 days, and 49 262 US dollars, respectively, for index admissions. On weighting the costs to estimate the economic burden on the healthcare system at a national level, the index admissions accounted for >2.6 billion US dollars in annual costs. Among those who survived, 5277 (20.2%) patients

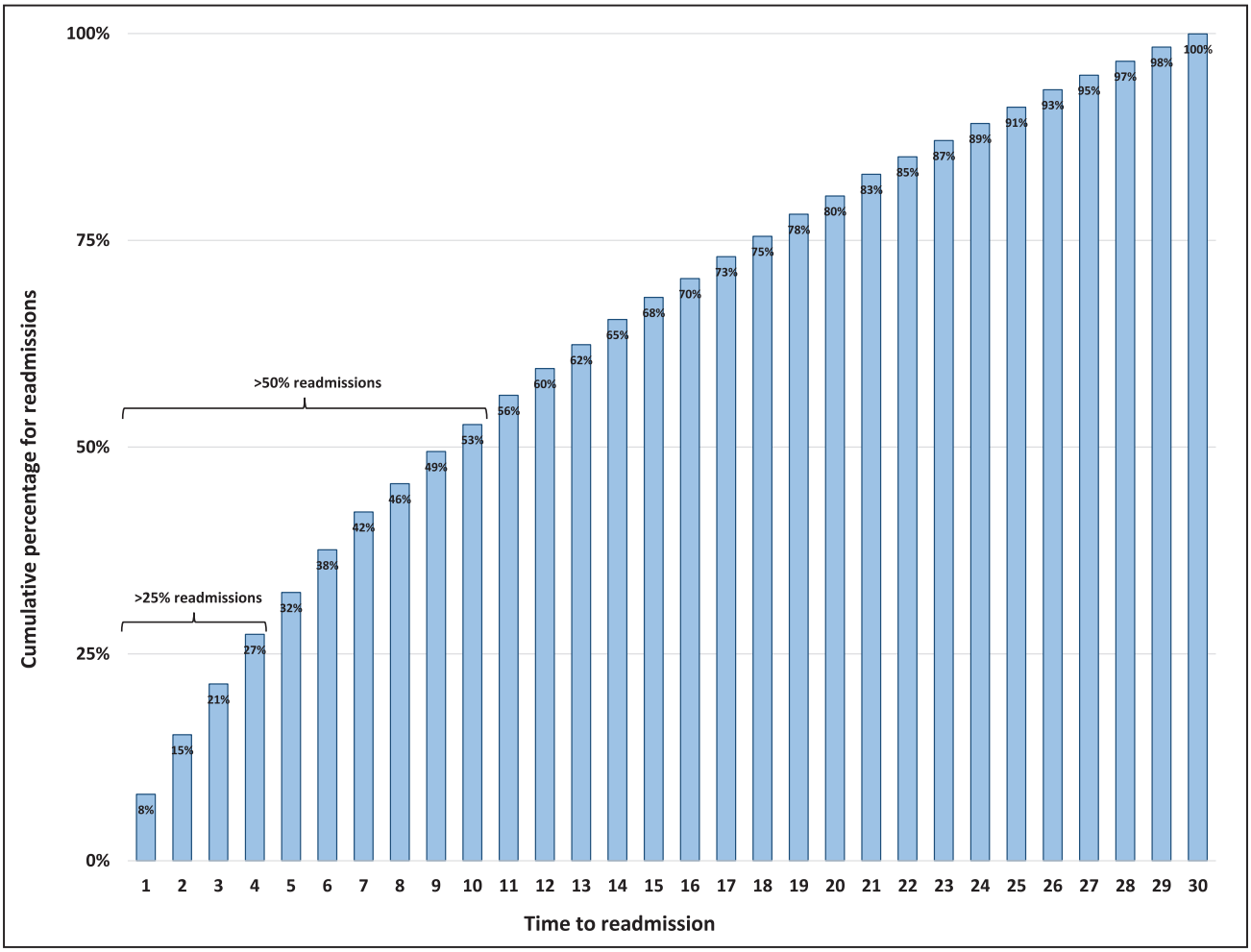

Figure 1. Cumulative frequency of readmission and time to 30-d readmission postdischarge from index hospitalization.

Table. Baseline Characteristics of Patients With Acute Myocardial Infarction and Cardiogenic Shock During Index Admission (Excluding Patients With In-Hospital Mortality)

Characteristics	Overall (n=26 016)	30-d Readmission		*P* Value
		Yes (n=5277)	No (n=20 739)	
Age, y, mean±SD	67.4±12.7	68.2±12.3	67.2±12.8	<0.001
Median age, y (IQR)	67 (59–77)	69 (60–77)	67 (58–77)	N/A
Age, y (categories)				<0.001
≤49	8.1	6.9	8.4	
50–64	32.5	29.8	33.2	
65–79	39.9	43.1	39.1	
≥80	19.4	20.3	19.2	
Female sex, %	35.3	38.5	34.5	<0.001
Weekend admission, %	25.8	25.6	25.8	0.75
Elective admission, %	6.5	6.3	6.6	0.38
Payer information, %				<0.001
Medicare	60.8	67.5	59.1	
Medicaid	9.4	10.0	9.3	
Private	21.3	16.3	22.5	
Self-pay	4.5	3.3	4.8	
No charge	0.6	0.5	0.6	
Other	3.4	2.4	3.7	
Cost of hospitalization in USD (mean)	59 646	65 808	58 091	<0.001
Median cost of hospitalization in USD (IQR)	43 203 (25 715–71 988)	47 683 (28 662–80 175)	42 191 (25 008–70 234)	n/a
Length of stay, d, mean±SD	14.0±14.5	16.0±14.3	13.5±14.5	<0.001
Median length of stay, d (IQR)	10 (6–17)	12 (7–20)	10 (6–17)	n/a
Length of stay categories, d				<0.001
≤2	5.6	3.1	6.2	
3–4	11.4	7.2	12.5	
5–7	18.5	15.8	19.2	
≥8	64.5	73.8	62.1	
Length of stay >30 d	8.6	10.9	8.0	<0.001
Median household income category for patient's zip code* (percentile)				0.03
0–25th	27.3	28.9	26.9	
26–50th	26.8	26.4	26.9	
51–75th	24.6	24.1	24.7	
76–100th	21.3	20.6	21.5	
Elixhauser comorbidity index (mean±SD)	3.7±2.0	4.1±2.1	3.5±2.0	<0.001
Charlson comorbidity index†				<0.001
≤1	10.4	6.4	11.5	
2	21.1	16.5	22.3	
3–4	39.8	40.1	39.7	
≥5	28.7	37.0	26.6	
Hospital bed size‡, %				0.01
Small	6.7	6.2	6.8	
Medium	22.0	20.8	22.3	
Large	71.3	73.0	70.9	
Location/teaching status of hospital, %				0.72
Urban nonteaching	33.2	33.4	33.2	
Urban teaching	63.2	63.3	63.2	
Rural	3.5	3.4	3.6	

(*Continued*)

Table. Continued

Characteristics	Overall (n=26 016)	30-d Readmission		*P* Value
		Yes (n=5277)	No (n=20 739)	
Year, %				0.40
2013	47.2	47.7	47.1	
2014	52.8	52.3	52.9	
Hypertension with and without complications, %	63.6	66.5	62.8	<0.001
Diabetes mellitus with and without complications, %	38.6	44.4	37.2	<0.001
Dyslipidemia, %	50.9	51.1	50.9	0.74
Chronic pulmonary disease, %	24.2	27.4	23.4	<0.001
Pulmonary hypertension, %	9.4	11.2	9.0	<0.001
Current or past smoker, %	34.8	31.9	35.6	<0.001
History of stroke or TIA, %	7.9	8.9	7.6	0.001
History of myocardial infarction, %	10.9	12.1	10.6	0.002
Drug abuse, %	3.4	3.6	3.3	0.32
Alcohol abuse, %	5.1	4.6	5.3	0.04
Peripheral vascular disorders, %	15.6	19.2	14.7	<0.001
Coagulopathy, %	19.7	20.7	19.4	0.03
Deficiency anemia, %	25.7	30.7	24.4	<0.001
Chronic blood loss anemia, %	1.5	1.6	1.5	0.45
Collagen vascular disease or rheumatoid arthritis, %	2.4	2.8	2.2	0.02
Hypothyroidism, %	10.5	11.4	10.3	0.01
Liver disease, %	2.5	3.1	2.3	0.001
Fluid and electrolytes disorders, %	53.1	56.9	52.1	<0.001
Obesity, %	15.9	16.3	15.7	0.32
Obstructive sleep apnea, %	5.8	6.0	5.8	0.70
Atrial fibrillation or flutter, %	30.7	34.3	29.7	<0.001
Acute kidney injury, %	46.2	51.1	45.0	<0.001
Chronic kidney disease, %	27.4	34.2	25.6	<0.001
Depression, %	7.2	7.8	7.0	0.03
Psychoses, %	3.3	4.0	3.1	0.001
Valvular heart disease, %	4.5	4.9	4.4	0.13
Vasopressor use, %	8.7	9.1	8.6	0.32
Ventilator use, %	43.9	46.1	43.4	0.001
Ischemic stroke, %	3.9	4.2	3.8	0.22
TIA, %	0.3	0.3	0.3	0.90
Hemorrhagic stroke, %	0.7	0.6	0.7	0.26
Systemic thromboembolic event, %	3.0	3.8	2.8	<0.001
Lymphoma, %	0.7	0.9	0.6	0.01
Metastatic cancer, %	1.1	1.3	1.0	0.03
Solid tumor without metastasis, %	1.9	2.3	1.8	0.007
Gastrointestinal bleeding, %	4.9	5.4	4.7	0.04
Hemoptysis, %	1.2	1.3	1.1	0.27
Prior venous thromboembolic event, %	2.1	2.4	2.0	0.03
Acute deep venous thrombosis, %	3.6	4.5	3.3	<0.001
Acute pulmonary embolism, %	1.7	1.5	1.7	0.25
Non–ST-segment–elevation myocardial infarction, %	54.5	58.6	53.5	<0.001

(*Continued*)

Table. Continued

Characteristics	Overall (n=26 016)	30-d Readmission		*P* Value
		Yes (n=5277)	No (n=20 739)	
ST-segment–elevation myocardial infarction, %	48.3	44.9	49.2	<0.001
Blood product transfusion, %	21.6	25.1	20.6	<0.001
Right heart catheterization, %	17.4	18.6	17.1	<0.001
Percutaneous coronary intervention, %	45.7	43.6	46.2	0.001
Single-vessel intervention	31.6	30.5	31.9	
2-vessel intervention	7.2	7.6	7.1	
≥3 vessel intervention	2.1	1.9	2.1	
Bifurcation vessel intervention	1.5	1.3	1.6	
Coronary artery bypass grafting, %	21.5	21.0	21.6	0.28
Durable ventricular assist device, %	0.6	0.9	0.5	0.001
Intraaortic balloon pump, %	34.7	35.3	34.6	0.35
Impella/TandemHeart, %	3.0	2.9	3.0	0.82
Extracorporeal membrane oxygenation, %	0.8	0.7	0.8	0.48
Vascular complications, %	2.6	3.0	2.6	0.09
Major bleeding event, %	11.8	13.0	11.5	0.003
Discharge disposition, %				<0.001
Home	39.2	32.2	41.0	
Short-term hospital	4.7	4.2	4.9	
SNF	31.7	37.7	30.1	
Home with HHC	23.5	24.9	23.1	

HHC indicates home healthcare; IQR, interquartile range; SNF, skilled nursing facility; TIA, transient ischemic attack; and USD, United States dollar.

*A quartile classification of the estimated median household income of residents in the patient's ZIP code, derived from ZIP code-demographic data obtained from Claritas. The quartiles are identified by values of 1 to 4, indicating the poorest to wealthiest populations. Because these estimates are updated annually, the value ranges vary by year.

†Charlson/Deyo comorbidity index (CCI) was calculated as per Deyo classification.

‡The bed size cutoff points divided into small, medium, and large have been done so that approximately one third of the hospitals in a given region, location, and teaching status combination would fall within each bed size category.

were readmitted within the first 30 days. More than 25% of the readmissions occurred within the first 4 days, and 50% readmissions occurred within 10 days of discharge from index hospitalization (Figure 1). Baseline characteristics of the entire study population have been reported in Table II in the Data Supplement.

The Table shows baseline characteristics among 26 016 patients who survived the index hospitalization for CS complicating AMI based on whether they were subsequently readmitted within 30 days of discharge. Compared with patients who were not readmitted, those readmitted within 30 days were likely to be older (≥65 years), less likely male, and had a higher prevalence of chronic conditions, such as hypertension, diabetes mellitus, atrial fibrillation, chronic kidney disease, chronic lung disease, peripheral vascular disease, and history of AMI among others. Readmitted patients also had higher comorbidity risk scores including Charlson (4.0±1.9 versus 3.5±1.8; *P*<0.001) and Elixhauser (4.1±2.1 versus 3.5±2.0; *P*<0.001) comorbidity indices.

Readmitted patients were more likely to have Medicare/Medicaid as their primary insurance payer and less likely to have private insurance compared with the nonreadmitted patients. There was no difference between the readmitted and nonreadmitted patients with respect to discharge from urban nonteaching, urban teaching, or rural hospitals at the end of index admission stay. Patients who were readmitted within 30 days had a higher incidence of fluid and electrolyte disorders, acute kidney injury, ventilator use, major bleeding event, acute deep venous thrombosis, discharge to skilled nursing facility, and a longer LOS and higher cost of stay during index hospitalization. Readmitted patients had a lower rate of revascularization (driven by lower rate of percutaneous coronary intervention), but similar rates of short-term mechanical circulatory support device use (intraaortic balloon pump [IABP], Impella/TandemHeart, and extracorporeal membrane oxygenation) compared with nonreadmitted patients. Although the rate of durable ventricular assist device (VAD) implantation was slightly higher among readmitted patients, the absolute implantation rate was as low as 0.6% within the group of patients that survived index hospitalization.

Cause, Length, and Cost of Stay for 30-Day Readmissions

There were a total of 6092 readmissions among 5277 patients. A total of 4544 patients had a single readmission, 656 patients had 2 readmissions, and 77 patients had ≥3 readmissions within 30 days. During the rehospitalization, use of short-term (IABP 1.4%; Impella/TandemHeart 0.2%; and extracorporeal membrane oxygenation 0.1%) and long-term (durable VAD 0.3%) mechanical circulatory support was low. Among the 30-day readmitted patients, there were additional 510 (9.6%) in-hospital deaths (Figure I in the Data Supplement).

Among the readmissions, 42% were because of cardiac causes, where heart failure (20.6%) was the commonest cause, followed by acute coronary syndrome (11.6%), atrial or ventricular arrhythmia (4.6%), and hypertensive disorder (1.9%). Majority of the noncardiac causes were because of pulmonary illnesses (11.4%) followed by infections (9.4%), gastrointestinal/hepatic/pancreatic diseases (6.5%), surgical or medical care-related complications (6.3%), kidney or genitourinary disorders (4.8%), neurological disorders (2.8%), shock/hypotension (1.9%), and hematologic disorders (1.4%) in addition to other causes described in Figure 2; Table IV in the Data Supplement.

Overall, LOS for readmissions was 7.3±9.1 days (median=5 days, interquartile range, 3–9 days) and cost of hospital stay was 20 690±36 979 US dollars (median=$10 635; interquartile range, $5694–$22 280). The total weighted cost of readmissions was >286 million US dollars for 2 years based on available data. Readmission-related costs accounted for 5.2% of total (index+readmissions) hospitalization costs associated with these patients.

Predictors of 30-Day Readmission

On multivariate analysis among those who survived to discharge (Figure 3; Table III in the Data Supplement), female sex (adjusted odds ratio [aOR], 1.09), LOS ≥8

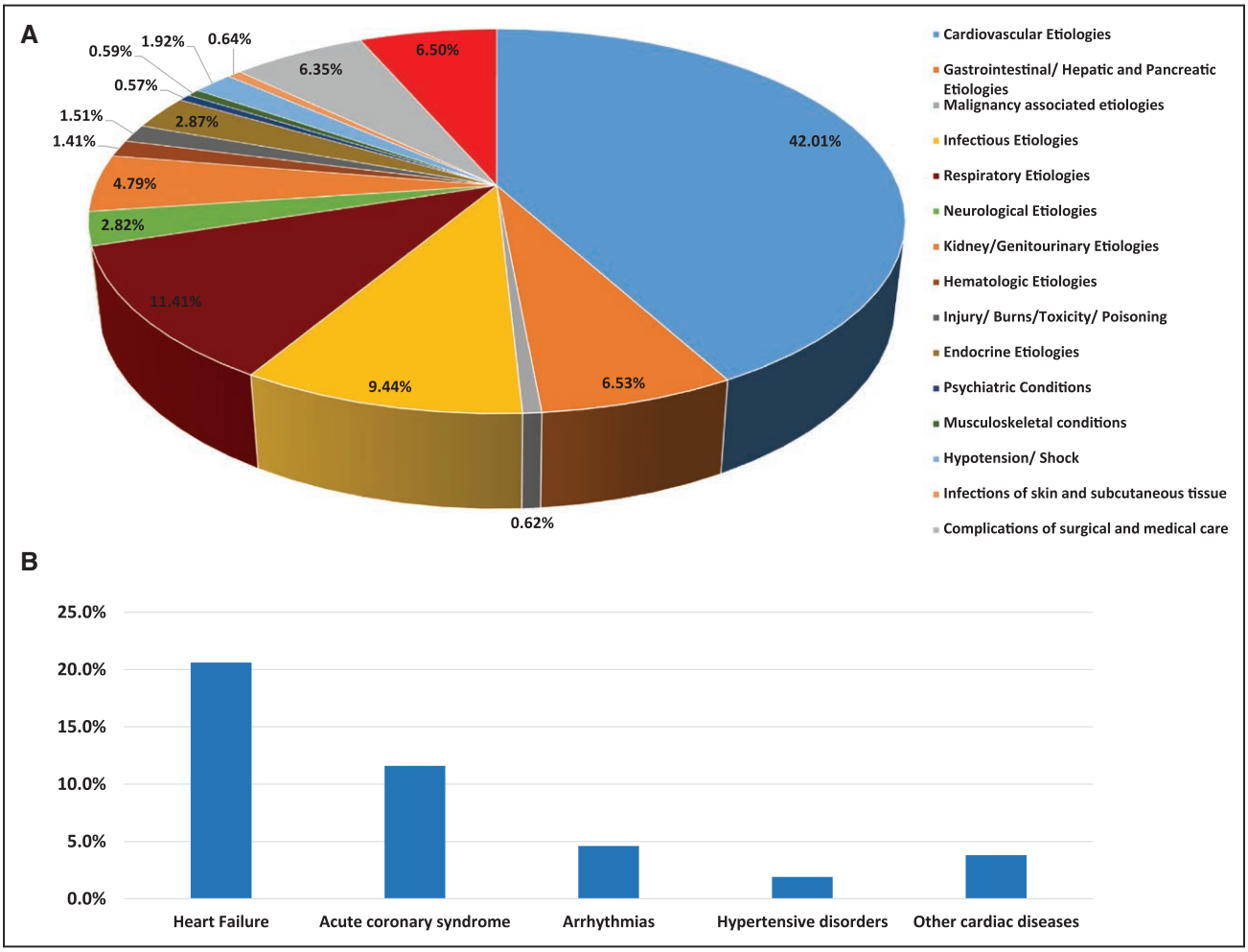

Figure 2. Causes of 30-d readmissions after index admission for cardiogenic shock complicating acute myocardial infarction.

A, All causes for 30-d readmission. **B**, Cardiovascular causes for 30-d readmission.

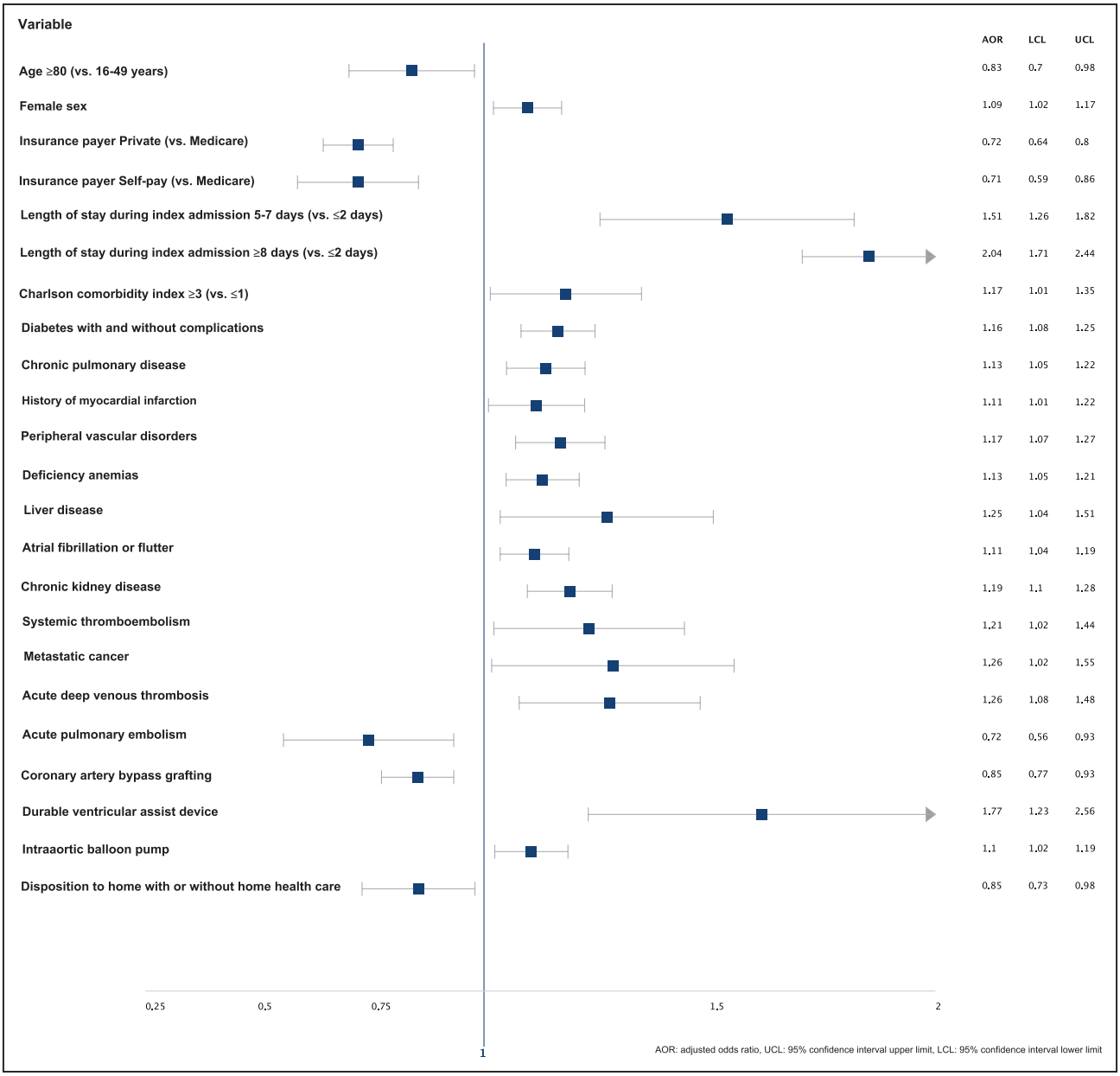

Figure 3. Independent predictors of 30-d readmission after index admission for cardiogenic shock complicating acute myocardial infarction.
AOR indicates adjusted odds ratio; LCL, confidence interval lower limit; and UCL, confidence interval upper limit.

days (aOR, 2.04), LOS 5 to 7 days (aOR, 1.51), acute deep venous thrombosis (aOR, 1.26), liver disease (aOR, 1.25), systemic thromboembolism (aOR, 1.21), CCI ≥3 (aOR, 1.17), chronic kidney disease (aOR, 1.18), peripheral vascular disease (aOR, 1.16), diabetes mellitus (aOR, 1.16), chronic lung disease (aOR, 1.13), deficiency anemias (aOR, 1.12), atrial fibrillation or flutter (aOR, 1.11), prior myocardial infarction (aOR, 1.11), metastatic cancer (aOR, 1.25), durable long-term VAD implantation (aOR, 1.77), and IABP use (aOR, 1.10) were identified as significant predictors of increased 30-day readmission. Performance of coronary artery bypass grafting (aOR, 0.85), private insurance payer (aOR, 0.72), self-pay (aOR, 0.71), and discharge to home (aOR, 0.85) independently predicted lower 30-day readmission.

DISCUSSION

In this extensive real-world study on all-cause readmissions related to CS complicating AMI, we showcase important findings: (1) In-hospital mortality was high during index admission (39.8%) and during subsequent readmission within 30 days (9.6%); (2) 20.2% of the patients who survived to discharge were readmitted within 30 days, and >50% of 30-d readmissions occurred within the first 10 days; (3) more than two

fifths of all 30-day readmissions were because of cardiac causes, with heart failure being the most common cause accounting for one fifth of all 30-day readmissions; (4) overall cost of readmissions was high, contributing to 5.2% of all hospital-related costs; and (5) female sex, LOS ≥5 days, CCI ≥3, chronic kidney disease, peripheral vascular disease, diabetes mellitus, systemic thromboembolism, and IABP or durable VAD use were among the factors that predicted increased 30-day readmission, whereas coronary artery bypass grafting, private insurance, and discharge to home predicted reduced 30-day readmission.

CS complicates 5% to 10% of all cases of AMI and is associated with high incidence of mortality and worse long-term outcomes when compared with patients presenting with AMI without CS. In-hospital mortality in CS has seen remarkable improvement in the past 2 decades with advent of early revascularization and increased utilization of appropriate treatment strategies including short-term mechanical circulatory support devices.[9,14] The overall in-hospital mortality seen within our patient cohort was 39.8% during the index admission and 9.6% during the subsequent readmission within 30 days. This rate is comparable to the 30-day mortality seen within the revascularization arm of the SHOCK trial (Should We Emergently Revascularize Occluded Coronaries for CS; 46.7%) and both arms of the IABP-SHOCK II trial (IABP arm, 39.7% and control arm, 41.3%), respectively.[10,15] Interestingly, the hospital mortality among our patients in our study during readmission was still significantly higher than what has been reported in recent studies including ST-segment–elevation myocardial infarction patients with multivessel coronary artery disease without CS (<5% in-hospital mortality).[16] This is suggestive of the heightened mortality risk patients with initial CS remain at, despite surviving the index admission.

Although questions remain on the validity of 30-day readmission as a surrogate for quality of care and clinical outcomes, it provides important insight into the disease process being evaluated and enables clinicians/hospitals to reassess their strategy and thereby improve their performance.[17,18] Analysis of the 2003 to 2004 claims data demonstrated a 19.6% 30-day readmission rate among Medicare beneficiaries, with a higher rate among medical patients compared with surgical (21.1% versus 15.6%).[19] A recent trend analysis of national all-cause 30-day readmissions noted relatively high readmission rates in conditions such as heart failure (23.5%), psychoses (22.7%), chronic obstructive pulmonary disease (20.0%), pneumonia (15.5%), and AMI (14.7%).[5] The trends revealed an overall downtrend in readmission among these conditions except pneumonias between 2009 and 2013, despite no significant change in the overall national readmission rate (14.0%–13.9%) across all cause index admissions. In our study of 43 212 patients with CS complicating AMI, the overall readmission rate was 20.3% among those who survived to discharge. This difference can be attributed to the high hospital mortality seen among admitted patients and the fact that even the survivors of shock have residual risk postdischarge. An analysis of readmissions within the SHOCK trial among 116 of the 144 survivors of index admission revealed that 45% of the patients needed readmission after discharge.[20] However, these interviews documenting readmission were conducted up to 15 months, and 30-day data were not described. On further investigating readmission cause, the authors noted a much higher proportion of readmissions for heart failure (42%), ischemic symptoms (31%), and other cardiac reasons (12%) compared with the cardiovascular cause readmissions (85% versus 42%) within our cohort. Several factors ranging from a small sample size and an interview-based documentation of readmissions in their study to use of primary *ICD-9* CM coding as cause for readmission in ours may have accounted for these differences. Shah et al[11] studied 112 668 AMI patients ≥65 years who survived their initial hospitalization and found that the patients with shock experienced a 33.9% rate of all-cause mortality or rehospitalization within 60 days of discharge. The rate of all-cause mortality within this patient group was 9.6% at 60 days, similar to the rate of 30-day in-hospital death noted during readmissions in our study. Heart failure–related readmissions accounted for 32.5% of all readmissions within 1 year of discharge among AMI patients with CS according to their analysis. Recent data on the proportion of 30-day readmissions occurring for cardiovascular causes in other cardiac disorders reveals similar rates posttransaortic valve replacement (38.2%) but relatively higher rates following admission for acute heart failure (51%).[21,22]

A validated risk prediction model focusing on mortality in CS was generated by Pöss et al[23] using clinical and demographic variables derived from the IABP-SHOCK II trial. The authors reported that older age, elevated creatinine at admission, higher lactate levels, prior strokes, high serum glucose, and thrombolysis in myocardial infarction flow grade <3 after percutaneous coronary intervention predicted higher short-term mortality. A separate analysis of the IABP-SHOCK II trial patients cohort revealed that females had a worse-risk profile than men; however, there were no sex-based differences in short- and long-term outcomes.[24] Although similar models predicting readmissions among patients with CS are lacking, our study showed how female sex, LOS ≥5 days, CCI ≥3, chronic kidney disease, liver disease, peripheral vascular disease, diabetes mellitus, chronic lung disease, deficiency anemias, atrial fibrillation, prior myocardial infarction, acute deep vein thrombosis, systemic thromboembolism, metastatic cancer, and IABP or durable VAD use predicted increased 30-day readmission. A 2013 study indicated that urgent revascularization is pursued more aggressively in ST-segment–elevation myocardial infarction–related

shock compared with non–ST-segment–elevation myocardial infarction–related CS; however, the presence of ST-segment–elevation myocardial infarction did not predict a change in readmissions according to our analysis. Use of VADs in critically ill patients with AMI resulted in a favorable mortality profile at 1-year post-VAD in a recent analysis, but planned and unplanned readmissions after left VAD placement are common.[25,26] Several of the factors that predicted higher readmission in CS in our study have been associated with worse outcomes when studied in other medical conditions.[27–29] More complete revascularization with coronary artery bypass grafting, better social support, and lesser frailty among those discharged to home may have been responsible for the lower readmission rates seen within that population.[29,30] Early follow-up after discharge and appropriate transition care measures should be promoted among survivors of CS, especially considering the higher upfront burden of readmissions immediately postdischarge.

The mean cost of stay and LOS among index admissions for CS complicating AMI was $51 506 and 11.0 days, respectively. The mean cost of stay per readmission was $20 690 and readmissions accounted for 5.2% of total hospitalization costs. Both the cost of stay and LOS among patients with CS were relatively higher than previously noted in patients admitted for cardiovascular disorders, such as heart failure, AMI, transaortic valve replacement, and noncardiovascular disorders with high morbidity and mortality such as severe sepsis.[21,22,31] Longer LOS, need for intensive care, cost of procedures such as PCI, coronary artery bypass grafting, cardiac/noncardiac surgery, and use of short- and long-term mechanical circulatory support devices are among the reasons for high costs among index CS admissions.[32,33] Although readmissions accounted for a relatively small portion of total costs, the mean cost per readmission was still several fold in comparison to other diseases. The overall annual cost impact of index admissions for CS complicating AMI (>2.6 billion US dollars) and 30-day readmissions (>143 million US dollars) poses a significant burden on a healthcare system already saddled with increased spending. A national health expenditure analysis revealed US healthcare spending to have increased 5.8% to a total of $3.2 trillion in the year of 2015.[34] Continued efforts on focused preventive care and increasing affordable access to healthcare may have potential in lowering the incidence and healthcare costs among those with coronary artery disease.[1,35,36]

Our study has several limitations, some of which are secondary to the administrative nature of our database, its reliance on *ICD-9* CM codes, and absence of clinical and laboratory data. Although the study attempted to analyze a contemporary cohort of patients with CS from the years of 2013 and 2014, it does represent >3-year-old data in a rapidly growing field. Detailed information on underlying coronary anatomy, extent of revascularization, severity of shock, medication use, and mechanical support is either limited or missing. Causes of readmission were identified using the primary discharge diagnosis codes. Patients readmitted to a hospital in a different state are not tracked in the NRD. The database is also inadequate in tracking mortality data on patients who died outside of a hospital or in the emergency department. Several of these limitations are mitigated by studying a large group of AMI-related CS admissions that are representative of real-world practice.

Patients with CS complicating AMI are at a significant risk for in-hospital and early postdischarge mortality. Hospitalization and readmissions among patients with CS complicating AMI adds a significant burden on healthcare resources and costs. Information on the causes and predictors for readmission will help clinicians and hospitals devise strategies to enhance outcomes, cost-effectiveness of management, quality of patient care and guide future resource allocation and healthcare policy.

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Correspondence

Mahek Shah, MD, Department of Cardiology, Lehigh Valley Health Network, 1250S Cedar Crest Blvd, Suite 300, Allentown, PA 18103. E-mail dr.mahekshah@yahoo.co.in

Affiliations

Department of Cardiology, Lehigh Valley Hospital, Allentown, PA (M.S., B.P., L.G.). Department of Medicine, University of Pittsburgh Medical Center, PA (S.P.). Department of Medicine, University of Tennessee Health Science Center, Memphis (M.A.). The Cardiovascular Center, Tufts Medical Center, Boston, MA (C.D.D., N.K.K.). Department of Cardiology, St Luke's University Health Network, Bethlehem, PA (S.A.). Department of Cardiology, Montefiore-Einstein Heart Center, Bronx, NY (U.P.J.).

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Disclosures

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