Use of Post−Acute Care Services and Readmissions After Acute Myocardial Infarction Complicated by Cardiac Arrest and Cardiogenic Shock

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Abstract

Objective: To evaluate post−acute care utilization and readmissions after cardiac arrest (CA) and cardiogenic shock (CS) complicating acute myocardial infarction (AMI).

Methods: With use of an administrative claims database, AMI patients from January 1, 2010, to May 31, 2018, were stratified into CA+CS, CA only, CS only, and AMI alone. Outcomes included 90-day post−acute care (inpatient rehabilitation or skilled nursing facility) utilization and 1-year emergency department visits and readmissions.

Results: Of 163,071 AMI patients, CA+CS, CA only, and CS only were noted in 3965 (2.4%), 8221 (5.0%), and 6559 (4.0%), respectively. In-hospital mortality was noted in 10,686 (6.6%) patients: CA+CS, 1935 (48.8%); CA only, 2948 (35.9%); CS only, 1578 (24.1%); and AMI alone, 4225 (2.9%) (P<.001). Among survivors, post−acute care services were used in 67,799 (44.5%), with higher use in the CS+CA cohort (1310 [64.6%]; hazard ratio [HR], 1.19; 95% CI, 1.06 to 1.33; P=.003) and CA cohort (2738 [51.9%]; HR, 1.27; 95% CI, 1.20 to 1.35; P<.001) but not in the CS cohort (3048 [61.2%]; HR, 1.03; 95% CI, 0.97 to 1.11; P=.35) compared with the AMI cohort (60,703 [43.3%]). Compared with the AMI cohort (48,990 [35.0%]), patients with CS only (2,085 [41.9%]; HR, 1.16; 95% CI, 1.10 to 1.22; P<.001) but not those with CA+CS (724 [35.7%]; HR, 1.07; 95% CI, 0.98 to 1.17; P=.14) had higher rates of readmissions (P=.03). Readmissions were lower in those with CA (1,590 [30.2%]; HR, 0.94; 95% CI, 0.89 to 0.99). Repeated AMI, coronary artery disease, and heart failure were the most common readmission reasons. There were no differences for emergency department visits.

Conclusion: CA is associated with increased post−acute care use, whereas CS is associated with increased readmission risk in AMI survivors.

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Cardiac arrest (CA) and cardiogenic shock (CS) complicate 5% to 10% of all acute myocardial infarction (AMI) admissions and are associated with a poor prognosis.[1-4] In-hospital outcomes have steadily improved in this critically ill population by multidisciplinary care, early percutaneous coronary intervention (PCI), standardized care protocols, bystander resuscitation, targeted temperature management, and judicious use of temporary mechanical circulatory support (MCS).[5,6] There are limited data on the long-term outcomes of these patients.[7-10] Studies examining older (≥65 years) AMI survivors suggested that CS but not CA is associated with higher long-term mortality.[8,11] Previous data from our group and others have shown that the combination of CS and CA is associated with worse short- and long-term mortality than either CA or CS alone.[12,13]

In addition to the high in-hospital mortality and resource utilization, patients with CS and CA complicating AMI remain vulnerable after discharge, with nearly 20% readmission rates within 30 to 90 days.[7,14,15] With the increasing emphasis on reducing hospitalizations to alleviate health care costs in the United States, it is crucial to understand the long-term health care utilization patterns in patients with CS or CA.[7,15] Although previous data have shown that CS is associated with high health care resource utilization after discharge,[7,15] the modulating effect of CA in patients with AMI is less understood.[8,11,13] Using a large administrative database, we sought to evaluate the use of post—acute care services, emergency department (ED) visits, and readmissions in survivors of AMI complicated by CA and CS. We hypothesized that AMI survivors with CA and CS during the index hospitalization would have a higher risk of readmissions, ED visits, and use of post—acute care services than AMI survivors with either CA or CS alone.

METHODS

Study Database, Population, and Variables

This study used deidentified administrative claims data from the OptumLabs Data Warehouse, which includes medical and pharmacy claims and enrollment records for commercial and Medicare Advantage enrollees. The database contains longitudinal health information of enrollees and patients, representing a diverse mixture of ages, ethnicities, and geographic regions across the United States.[16-18] The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure as access to the data requires a partnership with OptumLabs Data Warehouse. Because this study involved analysis of preexisting, deidentified data, it was exempt from Institutional Review Board approval.

In the period from January 1, 2010, through May 31, 2018, we identified all adult patients 18 years of age and older who were admitted with a primary or first secondary diagnosis of AMI (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] 410.x and *International Classification of Diseases, Tenth Revision, Clinical Modification* [ICD-10-CM] I21.x-22.x). Based on the presence or absence of CS (ICD-9-CM 785.51; ICD-10-CM R57.0) and CA (ICD-9-CM 427.5, 427.41, 99.60, and 99.63; ICD-10-CM I46.x, I49.01, and I49.02; ICD-10 *Procedure Coding System* 5A12012), this population was classified into four cohorts: CA+CS, CA only, CS only, and AMI alone (ie, no CS or CA).[2,19-26] The administrative codes for CS have been noted to have high positive predictive value (>90%) and specificity (>95%) but low sensitivity (>50%).[23,27] The administrative codes for CA show a high positive predictive value for the presence of CA but poor discrimination between in-hospital and out-of-hospital CA.[4,26] We required all patients to have continuous enrollment in a medical and prescription drug plan for at least 6 months before their index date. We excluded patients who were already hospitalized with their index myocardial infarction on the first day of the study period (January 1, 2010) or still hospitalized at the end of the study period (May 18, 2018).

Demographic characteristics (age, sex, and race), health plan coverage, comorbidities, and medication fills were identified from the OptumLabs Data Warehouse. The Deyo modification of the Charlson Comorbidity Index was used to determine the burden of comorbid diseases.[28] Consistent with previous literature, in-hospital variables such as acute noncardiac organ failure, use of coronary angiography, PCI, coronary artery bypass grafting, MCS, right-sided heart catheterization/pulmonary artery catheterization, and noncardiac organ support (invasive/noninvasive mechanical ventilation, hemodialysis) were identified by billing and procedure codes (Supplemental Table 1, available online at http://www.mayoclinicproceedings.org). Patients were observed until death, disenrollment from the health plan, or May 31, 2019, whichever came first.

Clinical Outcomes

The outcomes of interest included 1-year all-cause readmissions, ED visits within 1 year that did not result in a hospitalization, post—acute care utilization (inpatient rehabilitation and skilled nursing facility [SNF]) in the first 90 days after discharge, and percentage of days alive during follow-up. Reasons for readmissions were categorized according to the Agency for Healthcare Research and Quality

TABLE 1. Characteristics and outcomes of patients with AMI stratified by the presence of CA and CS[a,b]

Characteristics and outcomes	AMI+CA+CS (n=3965)	AMI+CA (n=8221)	AMI+CS (n=6559)	AMI only (n=144,326)	Total (N=163,071)	*P*
Age (y)	67.4±11.7	67.8±12.4	70.3±11.1	68.4±12.6	68.4±12.5	<.001
Sex						
Female	1302 (32.8)	2910 (35.4)	2641 (40.3)	59,243 (41.0)	66,096 (40.5)	<.001
Male	2663 (67.2)	5311 (64.6)	3918 (59.7)	85,083 (59.0)	96,975 (59.5)	
Race						
White	2885 (72.8)	5883 (71.6)	4658 (71.0)	103,799 (71.9)	117,225 (71.9)	<.001
Black	520 (13.1)	1241 (15.1)	897 (13.7)	21,134 (14.6)	23,792 (14.6)	
Hispanic	316 (8.0)	631 (7.7)	587 (8.9)	11,532 (8.0)	13,066 (8.0)	
Asian	125 (3.2)	204 (2.5)	216 (3.3)	3228 (2.2)	3773 (2.3)	
Unknown	119 (3.0)	262 (3.2)	201 (3.1)	4633 (3.2)	5215 (3.2)	
Census region						
Midwest	1155 (29.1)	2409 (29.3)	1982 (30.2)	43,862 (30.4)	49,408 (30.3)	<.001
Northeast	570 (14.4)	1169 (14.2)	1056 (16.1)	21,835 (15.1)	24,630 (15.1)	
South	1754 (44.2)	3839 (46.7)	2852 (43.5)	64,753 (44.9)	73,198 (44.9)	
West	486 (12.3)	804 (9.8)	669 (10.2)	13,876 (9.6)	15,835 (9.7)	
Insurance						
Commercial	1285 (32.4)	2595 (31.6)	1523 (23.2)	43,733 (30.3)	49,136 (30.1)	<.001
Medicare Advantage	2680 (67.6)	5626 (68.4)	5036 (76.8)	100,593 (69.7)	113,935 (69.9)	
Charlson Comorbidity Index	3.4±2.4	3.5±2.6	3.9±2.5	3.6±2.6	3.6±2.6	<.001
AMI type						
Non−ST-segment elevation	1322 (33.3)	3896 (47.4)	3251 (49.6)	102,758 (71.2)	111,227 (68.2)	<.001
ST-segment elevation	2611 (65.9)	4188 (50.9)	3251 (49.6)	38,927 (27.0)	48,977 (30.0)	
Unspecified	32 (0.8)	137 (1.7)	57 (0.9)	2641 (1.8)	2867 (1.8)	
Acute organ failure						
Respiratory	3494 (88.1)	4910 (59.7)	4377 (66.7)	34,623 (24.0)	47,404 (29.1)	<.001
Renal	2016 (50.8)	2830 (34.4)	3441 (52.5)	30,486 (21.1)	38,773 (23.8)	<.001
Hepatic	778 (19.6)	539 (6.6)	714 (10.9)	1230 (0.9)	3261 (2.0)	<.001
Hematologic	627 (15.8)	622 (7.6)	982 (15.0)	7669 (5.3)	9900 (6.1)	<.001
Metabolic	1376 (34.7)	1575 (19.2)	1588 (24.2)	8534 (5.9)	13,073 (8.0)	<.001
Neurologic	1863 (47.0)	2761 (33.6)	1330 (20.3)	12,258 (8.5)	18,212 (11.2)	<.001
Coronary angiography	2465 (62.2)	4949 (60.2)	4435 (67.6)	97,814 (67.8)	109,663 (67.2)	<.001
Percutaneous coronary intervention	2402 (60.6)	3865 (47.0)	3155 (48.1)	66,947 (46.4)	76,369 (46.8)	<.001
Coronary artery bypass graft	491 (12.4)	619 (7.5)	1640 (25.0)	11,635 (8.1)	14,385 (8.8)	<.001
Right-sided heart/pulmonary artery catheterization	918 (23.2)	761 (9.3)	2145 (32.7)	12,157 (8.4)	15,981 (9.8)	<.001
MCS						
IABP	1679 (42.3)	435 (5.3)	2566 (39.1)	2454 (1.7)	7134 (4.4)	<.001
Percutaneous MCS	330 (8.3)	41 (0.5)	332 (5.1)	211 (0.1)	914 (0.6)	<.001
Nonpercutaneous MCS	184 (4.6)	14 (0.2)	194 (3.0)	70 (0.0)	462 (0.3)	<.001
ECMO	111 (2.8)	<11 (0.0)	59 (0.9)	<11 (0.0)	—	<.001
Invasive mechanical ventilation	2864 (72.2)	3860 (47.0)	2131 (32.5)	5246 (3.6)	14,101 (8.6)	<.001
Noninvasive mechanical ventilation	107 (2.7)	287 (3.5)	385 (5.9)	4140 (2.9)	4919 (3.0)	<.001
Hemodialysis	409 (10.3)	374 (4.5)	545 (8.3)	3170 (2.2)	4498 (2.8)	<.001
Electroencephalography	<11 (0.0)	25 (0.3)	<11 (0.0)	89 (0.1)	—	<.001
In-hospital mortality	1935 (48.8)	2948 (35.9)	1578 (24.1)	4225 (2.9)	10,483 (6.4)	<.001
Hospital length of stay (d)	11.9±18.3	8.0±13.6	12.0±15.4	5.4±7.4	6.0±8.9	<.001
Discharge disposition						
Hospice	107 (2.7)	194 (2.4)	314 (4.8)	3170 (2.2)	3785 (2.3)	<.001
Against medical advice	<11 (0.0)	13 (0.2)	12 (0.2)	619 (0.4)	649 (0.4)	

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TABLE 1. Continued

Characteristics and outcomes	AMI+CA+CS (n=3965)	AMI+CA (n=8221)	AMI+CS (n=6559)	AMI only (n=144,326)	Total (N=163,071)	*P*
Discharge disposition, continued						
Reserved	0 (0.0)	0 (0.0)	<11 (0.0)	0 (0.0)	<11 (0.0)	
Reserved for national assignment	0 (0.0)	0 (0.0)	0 (0.0)	<11 (0.0)	<11 (0.0)	
Still confined	11 (0.3)	<11 (0.0)	<11 (0.0)	59 (0.0)	—	
Transferred	613 (15.5)	938 (11.4)	1425 (21.7)	21,385 (14.8)	24,361 (14.9)	
Unknown	20 (0.5)	37 (0.5)	24 (0.4)	89 (0.1)	170 (0.1)	

[a]AMI, acute myocardial infarction; CA, cardiac arrest; CS, cardiogenic shock; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pump; MCS, mechanical circulatory support.
[b]Represented as number (percentage) or mean ± standard deviation; all comparisons made using 1-way analysis of variance.

Clinical Classifications Software.[15] Readmissions for PCI or coronary artery bypass grafting within 60 days of discharge from the index hospitalization were considered staged procedures/planned hospitalizations unless a diagnostic code consistent with an acute cardiac event (heart failure, AMI, atrial or ventricular arrhythmia, CS, or CA) was present.[11,29] Post–acute care utilization was identified by billing codes. SNF stays were identified by UB-04 Revenue Codes 0550, 0551, 0552, 0559, and 0658; *Current Procedural Terminology*, 4th edition, codes 99304-99313, 99315, 99316, and 99318; and Healthcare Common Procedure Coding System code Q5004.[30] Inpatient rehabilitation was identified by UB-04 Revenue Codes 0118, 0128, 0138, 0148, 0158, and 0943.

Statistical Analyses

The differences in baseline characteristics in the 4 cohorts (CA+CS, CA only, CS only, and AMI alone) were compared by the χ^2 test (categorical variables) and 1-way analysis of variance (continuous variables). Patients were censored at the date of the end of coverage, in-hospital death, orthotopic heart transplant, or 90 days (post–acute care analysis) or 1 year (ED visits and readmissions analysis), whichever came first. The unadjusted cumulative event rates were estimated by Kaplan-Meier methods and displayed separately for the 4 cohorts. Causes of readmissions were described with summary statistics. Cox proportional hazards models were used to calculate hazard ratios (HRs) and 95% CI for risks of any all-cause readmissions, any ED visits, and post–acute care use by the AMI cohort, separately, after adjustment for potential confounders. The proportional hazard assumption was tested by examination of Schoenfeld residuals. Multivariable adjustment was performed for age, sex, race, census region, comorbidity, acute organ failure, use of coronary angiography, PCI, right-sided heart catheterization, pulmonary artery catheterization, MCS, noninvasive ventilation, invasive mechanical ventilation, hemodialysis, and length of index hospital stay. For days alive at 1-year analysis, patients with incomplete follow-up during the 12-month period were excluded. Two-tailed *P* less than .05 was considered statistically significant. All analyses were conducted using SAS 9.4 (SAS Institute) and Stata 13.1 (StataCorp) software.

RESULTS

During the 8 years of the study, there were 163,071 patients admitted with a primary diagnosis of AMI, of which CA and CS were present in 12,186 (7.5%) and 10,524 (6.5%), respectively. Both CA and CS were present in 3965 (2.4%) patients. The baseline characteristics of the 4 cohorts are presented in Table 1 and Supplemental Table 2 (available online at http://www.mayoclinicproceedings.org). Patients with CA on average had fewer comorbidities, were more frequently male, had higher rates of ST-segment elevation AMI, and less frequently received coronary angiography (Table 1). PCI, MCS, invasive mechanical ventilation, and hemodialysis were used more frequently in the cohort with CA+CS compared with the cohorts with CA only or CS only (Table 1). In-hospital mortality was highest in the CA+CS cohort (1935 [48.8%]) compared with the CA only (2948 [35.9%]) and CS only (1578

TABLE 2. Post−acute care ED visits and readmissions in AMI survivors stratified by the presence of CA and CS[a,b]

Characteristics and outcomes	AMI+CA+CS (n=2028)	AMI+CA (n=5272)	AMI+CS (n=4981)	AMI only (n=140,062)	Total (N=152,343)	*P*
Person-years available	1477.32	4051.81	3671.35	111,190.30	120,390.79	
Post−acute care use within 90 days						
Overall	1310 (64.6)	2738 (51.9)	3048 (61.2)	60,703 (43.3)	67,799 (44.5)	<.001
SNF and rehabilitation	178 (8.8)	212 (4.0)	418 (8.4)	3698 (2.6)	4506 (3.0)	
Rehabilitation	507 (25.0)	1271 (24.1)	791 (15.9)	22,703 (16.2)	25,272 (16.6)	
SNF	625 (30.8)	1255 (23.8)	1839 (36.9)	34,302 (24.5)	38,021 (25.0)	
None	718 (35.4)	2534 (48.1)	1933 (38.8)	79,359 (56.7)	84,544 (55.5)	
ED visits within 1 year	1358 (67.0)	3870 (73.4)	3712 (74.5)	112,483 (80.3)	121,423 (79.7)	<.001
Rate per 100 person-years	91.9	95.5	101.1	101.2	100.9	<.001
ED visits within 1 year						
0	1300 (64.1)	3321 (63.0)	3108 (62.4)	85,479 (61.0)	93,208 (61.2)	<.001
1	418 (20.6)	1131 (21.5)	1051 (21.1)	30,264 (21.6)	32,864 (21.6)	
2	170 (8.4)	445 (8.4)	419 (8.4)	12,231 (8.7)	13,265 (8.7)	
3+	140 (6.9)	375 (7.1)	403 (8.1)	12,088 (8.6)	13,006 (8.5)	
Total readmissions within 1 year	1320 (65.1)	2878 (54.6)	4028 (80.9)	90,136 (64.4)	98,362 (64.6)	<.001
Rate per 100 person-years	89.4	71.0	109.7	81.1	81.7	<.001
Total readmissions within 1 year						
0	1304 (64.3)	3682 (69.8)	2896 (58.1)	91,072 (65.0)	98,954 (65.0)	<.001
1	432 (21.3)	968 (18.4)	1130 (22.7)	28,281 (20.2)	30,811 (20.2)	
2	145 (7.1)	314 (6.0)	492 (9.9)	10,924 (7.8)	11,875 (7.8)	
3+	147 (7.2)	308 (5.8)	463 (9.3)	9785 (7.0)	10,703 (7.0)	
Percentage of days alive within 1 year[c]	83.9±30.6	87.7±27.4	82.4±30.8	89.1±24.7	88.7±25.1	<.001

[a]AMI, acute myocardial infarction; CA, cardiac arrest; CS, cardiogenic shock; ED, emergency department; SNF, skilled nursing facility.
[b]Represented as number (percentage) or median (interquartile range); all comparisons made using 1-way analysis of variance.
[c]Excluded patients with end of coverage within 12 months of follow-up.

[24.1%]) cohorts (Table 1). The CA only and AMI only cohorts had shorter in-hospital lengths of stay compared with the CA+CS and CS only cohorts (Table 1). AMI patients with CS only were discharged more frequently to hospice compared with the CA+CS and CA only cohorts (Table 1). The baseline characteristics of those who survived to hospital discharge in the 4 cohorts are presented in Supplemental Table 2.

During the 90-day period after the index hospitalization, 67,799 (44.5%) patients used post−acute care services, including 38,021 (25.0%) who were cared for in an SNF, 25,272 (16.6%) who participated in inpatient rehabilitation, and 4506 (3.0%) who used both. The patients with CA+CS and CS had higher rates of post−acute care use compared with those with CA only and AMI only ($P<.001$; Table 2). CS was associated with higher use of SNF, whereas CA was associated with higher use of rehabilitation. Combined SNF and rehabilitation use was higher in those with CS, with or without CA (418 [8.4%]), whereas it was infrequently used in those with AMI only (3698 [2.6%]; Table 2). After adjustment for potential confounders, compared with the AMI only cohort, the cohort with CS+CA (HR, 1.19; 95% CI, 1.06 to 1.33; $P=.003$) and the cohort with CA only (HR, 1.27; 95% CI, 1.20 to 1.35; $P<.001$) but not the CS only cohort (HR, 1.03; 95% CI, 0.97 to 1.11; $P=.35$) had greater use of post−acute care services (Supplemental Table 3, available online at http://www.mayoclinicproceedings.org).

Patients with CS, either alone or in combination with CA, had more frequent (≥3) ED visits (Table 2). The number of ED visits varied between 0 and 171, with the highest number of ED visits in patients with AMI alone and the lowest number for the cohort with CA+CS

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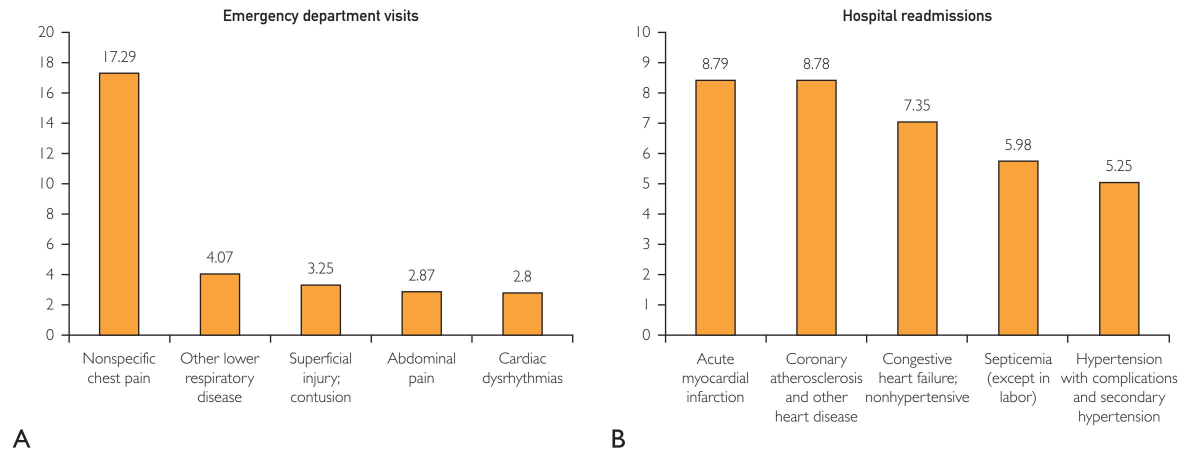


FIGURE 1. Top 5 reasons for emergency department visits and hospital readmissions. A, Emergency department visits. B, Hospital readmissions.

(Table 2). The most common causes of ED visits included nonspecific chest pain, lower respiratory tract infection, and superficial contusion (Figure 1A; Supplemental Table 4, available online at http://www.mayoclinicproceedings.org). After adjustment for significant confounders, there was no difference between groups in risk of ED visits in survivors (Figure 2; Supplemental Table 3).

The number of rehospitalizations varied between 0 and 26, and the cohort with CS alone had the highest proportion of patients with at least 1 (2,085 [41.9%]) and 3 or more (463 [9.3%]) hospitalizations (Table 2). AMI, coronary artery disease, and heart failure constituted the most common reasons for hospital readmissions in the overall cohort (Figure 1B; Supplemental Table 4). After adjustment for potential confounders, compared with the AMI only cohort, the cohort with CS only (HR, 1.16; 95% CI, 1.10 to 1.22; $P<.001$) but not those with CA+CS (HR, 1.07; 95% CI, 0.98 to 1.17; $P=.14$) had higher risk of hospitalizations during the year after AMI (Figure 3; Supplemental Table 3). Patients with CA only (HR, 0.94; 95% CI, 0.89 to 0.99; $P=.03$) had a lower risk of subsequent hospitalization.

DISCUSSION

In the study of patients enrolled in commercial and Medicare Advantage health plans, we continued to note high in-hospital mortality associated with CA and CS in AMI. Of the survivors, nearly half (45%) used post—acute care services in the 90 days after hospital discharge, and 39% and 35% of patients, respectively, experienced ED visits and readmissions in the year after AMI. The presence of CA, either alone or in combination with CS, was associated with post—acute care utilization. In contrast, CS was associated with a higher risk of hospital readmission during the subsequent 1-year period.

Previous data from the Medicare population have shown that the greatest risk in AMI+CS patients is during the first 6 months after discharge.[11,31] Using the CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation of the ACC/AHA Guidelines) registry, Bagai et al[31] found no differences in "days alive and out of hospital" after the first 6 months beyond AMI+CS in older AMI+CS adults who survived the hospitalization. Similarly, using the ACTION-GWTG (Acute Coronary Treatment and Intervention Outcomes Network Registry—Get With the Guidelines) registry, Fordyce et al[8] did not find significantly different 1-year outcomes in AMI survivors with and without CA.

Post—acute care utilization is common after acute hospitalization and represents a significant burden to the health care system.[32]

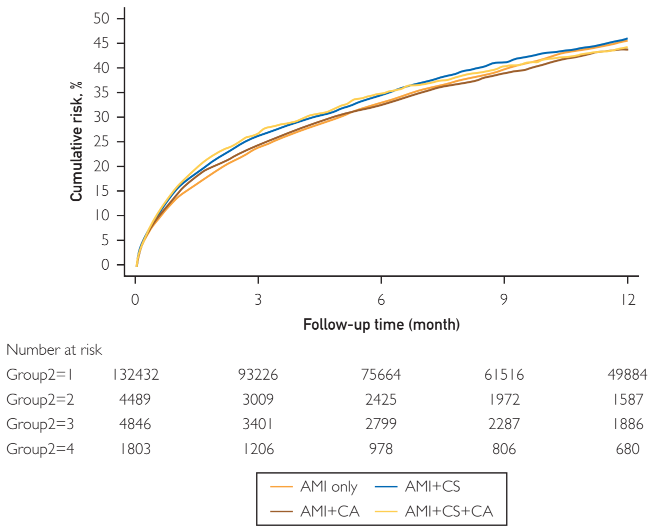


FIGURE 2. Kaplan-Meier time-to-event curves for emergency department visits in acute myocardial infarction (AMI) survivors with and without cardiac arrest (CA) and cardiogenic shock (CS).

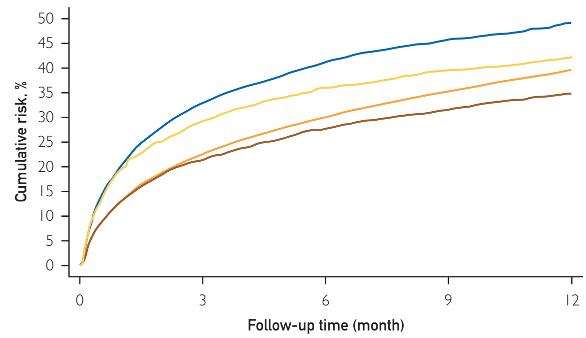
Although CS did not independently predict the need for post–acute care utilization, the combination of CA and CS was associated with higher utilization. The overall use of post–acute care services remained high in this critically ill population. After an AMI hospitalization, either with or without concomitant CS or CA, patients often have decreased mobility because of prolonged immobilization and activity restriction.[31] In patients with CA and CS, the additional presence of neurologic injury, need for mechanical ventilation or hemodialysis, prolonged immobilization, iatrogenic trauma from resuscitation, and long-term medications result in higher use of post–acute care resources.[11] These data highlight the vulnerable phase during post–acute care admissions in AMI patients, especially those with CA.

In contrast to the post–acute care use, this study found that CS but not CA is associated with increased readmission risk in the year after AMI. These data are consistent with previous work from other databases. Using the Nationwide Readmissions Database, Atti et al[33] and Shah et al[15] reported nearly 20% of all AMI+CS survivors to be readmitted within 30 days. Jeger et al[34] found a nearly 45% 30-day readmission rate in survivors from the SHOCK (SHould we emergently revascularize Occluded Coronaries in cardiogenic shocK?) trial. These AMI+CS studies found heart failure to be the leading cause of readmissions, whereas in this current all-comer AMI study, we note repeated AMI to be the most common cause of readmission. Importantly, 4 of our top 5 reasons for readmission were cardiac in etiology: AMI, coronary artery disease, heart failure, and hypertension with complications. In comparison to the previous data, we provide a more contemporary, longitudinal, and longer (1-year) assessment of readmission outcomes in AMI survivors. CA typically is manifested with the highest risk upfront, and complications such as brain injury, shock, and organ failure typically develop at the beginning of the clinical course and improve with time among survivors.[5] Furthermore, the majority of the deaths in CA are due to neurologic injury, with a relative minority from circulatory failure or multiorgan dysfunction, and survivors without neurologic injury appear to do well long term.[35] In contrast, CS in AMI follows a "hemo-metabolic" cascade wherein the initial hemodynamic insult from myocardial injury spirals into metabolic failure, resulting in peripheral hypoperfusion and multiorgan failure culminating in death or persistent myocardial and organ dysfunction among survivors.[2,36-40] These findings have important implications for AMI survivors since the Hospital Readmissions Reduction Program implemented by the U.S. Centers for Medicare & Medicaid Services has included AMI starting in 2012.[15,33] However, policymakers and physicians have recently raised concern that the Hospital Readmissions Reduction Program may have also had unintended consequences that adversely affected patient care, potentially leading to increased mortality.[41]

This study has several limitations that are inherent to the analysis of large administrative databases. The use of administrative codes without primary data may be associated with biases relating to undercoding or overcoding. This was a retrospective observational study, so no causal inferences can be made. The data source includes patients enrolled in commercial and Medicare Advantage health plans with pharmacy benefits, and findings in other populations may differ. We do not have information on coronary anatomy, hemodynamic details, or timing of CS and CA (at presentation vs in the hospital), left ventricular function, and completeness of revascularization, limiting further patient-specific risk assessment. The administrative codes for CA have shown poor sensitivity in differentiating between out-of-hospital and in-hospital CA, and therefore we have not specifically evaluated these entities separately.[4] Although CS was most likely a direct consequence of AMI, the presence of reversible post-CA myocardial dysfunction could have contributed to the development of CS in patients with CA.[35] Given the administrative nature of this database, we cannot accurately distinguish type 1 from type 2 non—ST-segment elevation AMI. However, this study included admissions with a primary diagnosis or first secondary diagnosis of AMI (ie, the reason most likely for the admission) and therefore is less likely to include type 2 non—ST-segment elevation AMI, which often has an alternative primary diagnosis. We were able to capture health care utilization occurring while patients remained enrolled in the health plan but could not capture usage after the end of the coverage. To accurately capture comorbidity burden and baseline risk, we required patients to have 6 months of continuous coverage before AMI to be included in the analysis, and these patients may differ from those who recently acquired coverage. Last, the reasons for post—acute care utilization were not delineated in this administrative study. Despite these limitations, this study addresses an important knowledge gap highlighting the long-term resource utilization of AMI patients with CA and CS either alone or in combination.

CONCLUSION

Post—acute care use was high in survivors of AMI, and the presence of CA, either alone or in combination with CS, was associated with even higher post—acute care utilization. In contrast, CS was associated with an increased risk of 1-year hospital readmissions, which were most commonly cardiovascular. Further studies aimed at understanding the interaction of these disease states and their correlation with socioeconomic and demographic factors that determine health care utilization are needed to optimize clinical outcomes in this population.



Number at risk

	0	3	6	9	12
Group2=1	132432	96012	81149	68661	57449
Group2=2	4489	2805	2289	1896	1570
Group2=3	4846	3556	3039	2628	2236
Group2=4	1803	1177	992	858	734

FIGURE 3. Kaplan-Meier time-to-event curves for hospital readmissions in acute myocardial infarction (AMI) survivors with and without cardiac arrest (CA) and cardiogenic shock (CS).

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://www.mayoclinicproceedings.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **AMI** = acute myocardial infarction; **CA** = cardiac arrest; **CS** = cardiogenic shock; **ED** = emergency department; **HR** = hazard ratio; **ICD-9-CM** = *International Classification of Diseases, Ninth Revision, Clinical Modification*; **ICD-10-CM** = *International Classification of Diseases, Tenth Revision, Clinical Modification*; **MCS** = mechanical circulatory support; **PCI** = percutaneous coronary intervention; **SNF** = skilled nursing facility

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