Causes, Trends, and Predictors of 90-Day Readmissions After Spontaneous Coronary Artery Dissection (from A Nationwide Readmission Database)

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Spontaneous coronary artery dissection (SCAD) is a frequently missed diagnosis in patients presenting with acute coronary syndrome (ACS). Our aim was to evaluate the causes, trends, and predictors of 90-day hospital readmission in patients presenting with SCAD. The Nationwide Readmissions Database (2013 to 2014) was utilized to identify patients with primary discharge diagnosis of SCAD using the International Classification of Diseases, Ninth Revision, Clinical Modification, diagnostic code 414.12. The primary outcome was 90-day readmission. Among 11,228 patients admitted with the primary diagnosis of SCAD, 2,424 patients (21.6%) were readmitted within 90 days (68% women, 82% <65 years of age). Common causes for 90-day readmission were ACS (25%), acute heart failure (11%), acute respiratory failure (7%), and arrhythmias (5%). Multivariate predictors of 90-day readmissions were hypertension, chronic obstructive pulmonary disease, peripheral arterial disease, discharge to facility and increased length of stay (LOS) during index admission. Multivariate predictors of increased healthcare-related costs were older age, female gender, discharge to facility, and increased LOS. Over half of the readmissions (52%) occurred in first 30 days after discharge. In conclusion, we found a high rate of rehospitalization among SCAD patients, particularly within the first 30 days of index hospitalization. ACS, heart failure, and acute respiratory failure were the most common reasons for readmission. Hypertension, chronic obstructive pulmonary disease, peripheral arterial disease, and increased LOS were independent predictors of readmission. Further studies are warranted to confirm these predictors of readmission in this high-risk population. **(Am J Cardiol 2019;124:1333−1339)**

Spontaneous coronary artery dissection (SCAD) is a frequently underdiagnosed clinicopathologic entity which is associated with significant morbidity and mortality. True prevalence of SCAD is uncertain but recent analysis from national databases reported a prevalence rate of 0.49%.[1] The clinical symptoms associated with SCAD are wide ranging and include chest discomfort, nausea, as well as arm, neck and back pain.[2] Importantly, SCAD may be present in up to a third of all young women presenting with acute coronary syndrome (ACS) and can result in sudden cardiac deaths in 0.5% of these patients.[3−5] Although pathogenesis of SCAD remains unclear, intimal tearing of the coronary arterial wall,[6] and disruption of vasa vasorum within the coronary arterial media possibly mediated by female hormones and/or genetic risk factors are some of the possible underlying mechanisms.[7] Although the majority of patients presenting with SCAD are younger women with few atherosclerotic disease risk factors, recurrent ischemia and hospital readmissions remain common and a minority of patients (3%) who are managed conservatively on index admission require hospital readmission for revascularization.[8] Since the data on factors associated with readmission remain limited, we sought to evaluate the causes, trends and predictors of 90-day readmission in patients presenting with SCAD.

Methods

The Healthcare Cost and Utilization Project's National Readmission Database (NRD) was used to identify all patients with a primary diagnosis of SCAD from January 2013 to December 2014 in the United States. The NRD (which is sponsored by the Agency for Healthcare Research and Quality) is one of the largest publicly available all-payer inpatient care databases in the United States. The

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database includes data on approximately 15 million discharges for the time-period from January 2013 to December 2014 across 22 states with reliable, verified linkage numbers. National estimates of the entire US population can be calculated through the use of provided weighting algorithms.[9] Patients were tracked during same year using variable "NRD visitlink," and the time between 2 admissions was calculated by subtracting variable "NRD_Days To Event."

Patients with SCAD were identified by querying the NRD database using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnostic code for SCAD (414.12). NRD variables were used to identify patients' demographic characteristics including age and gender, hospital characteristics such as bed size and teaching status, and other patient-specific characteristics, including median household income category for patient's zip code, primary payer, admission type, admission day, and discharge disposition.[10] Co-morbidities such as obesity, hypertension, heart failure (HF), chronic obstructive pulmonary disease (COPD), peripheral arterial disease (PAD), diabetes mellitus, anemia, neurological disease or paralysis, hematological or oncological malignancy and renal failure were also identified by variables provided in NRD.[11] Severity of co-morbid conditions was defined using Deyo modification of Charlson co-morbidity index, which contains co-morbid conditions with differential weights. The score ranges from 0 to 33, with greater scores corresponding to greater burden of co-morbid diseases.[12] We excluded patients age <18 years old as well as those patients with missing data for age, gender, or mortality. We also excluded all index admissions in the months of October, November, and December as they lacked 90-day follow-up data. Similar methods were used that were described previously.[9,13,14]

Patients who were readmitted to the hospital within 90 days within the same calendar year underwent further assessment of the primary and secondary outcomes. The primary outcome of our study was the rate of readmission at 90 days. Secondary outcomes included trends, causes, and predictors of 90-day readmission. Causes of readmission were identified using the primary ICD-9 diagnosis codes filed during readmission.

SAS 9.4 (SAS Institute Inc., Cary, North Carolina) was utilized for analyses. Differences between categorical variables were tested using the chi-square test and differences between continuous variables were tested using student *t* test. Hierarchal 2-level logistic regression model with hospital ID as random effect was used to evaluate secondary outcomes. The variables included in the 90-day multivariate readmission model were hospital level characteristics such as hospital teaching status and bed size; patient's demographics such as age and gender; co-morbid conditions such as obesity, hypertension, HF, COPD, PAD, diabetes mellitus, anemia and renal failure; and other patient level characteristics such as primary payer, median household income and disposition after hospital discharge. Multivariable predictors of increased healthcare-related cost during index hospitalization were also assessed. p value of less than 0.05 was considered significant for our study.

Results

During study period, a total of 11,228 patients with a principle discharge diagnosis of SCAD were identified. Among these, 2,424 (22%) were readmitted within 90 days of discharge from index admission. Majority of these patients were women and younger than 65 years of age. Hypertension, diabetes mellitus, COPD, PAD, and anemia were the most common co-morbidities (Table 1). High co-morbidity burden was noted in 44% of patients as indicated by co-morbidity index ≥2. Average LOS of index admission was 5.3 days. Most of the patients were discharged to home (85%). In-hospital mortality rate on the index hospitalization was 6%.

Median time for readmissions was 29 days post discharge (Figure 1). Cardiac conditions were the most common causes (55.4%) for readmission. Among cardiac conditions, ischemic heart disease was most frequent, followed by HF and arrhythmias. The most common noncardiac causes included pulmonary conditions, infections, and bleeding complications (Figure 2).

Multivariate predictors of 90-day readmission after the index admission for SCAD are shown in Table 2. Co-morbidities such as hypertension, COPD, and PAD were significant predictors of readmission, whereas age >65 years was associated with fewer readmissions. Patients who were discharged to a facility or had increased LOS during index hospitalization were more likely to be readmitted within 90 days of index hospitalization.

Multivariate model for increased healthcare-related cost during index hospitalization is provided in Table 3. Age >65 years, female gender, discharge to a facility or increased LOS during index hospitalization were independent predictors of increased cost of care.

Discussion

In this large nationwide observation study, we evaluated the causes and predictors of 90-day readmission for patients with SCAD. The major findings of our study are: (1) among patients who survived an index hospitalization for SCAD, 22% were readmitted within 90 days (with more than half of readmissions occurring within the first 30 days); (2) the most common etiologies of 90-day readmissions were ACS, acute HF, acute respiratory failure and cardiac arrhythmias; (3) hypertension, COPD, PAD, and LOS during index hospitalization were identified as independent predictors of 90-day readmission; (4) age >65 years, female gender, discharge to facility, and increased length of hospital stay were independent factors that predicted increased healthcare-related cost among patients with SCAD.

SCAD was initially described by Pretty in 1931 as a clinical entity that was distinct from other causes of ACS.[15] In a Denmark Heart Registry, SCAD was found in 0.2% of all patients resenting with ACS.[16] We observed a 22% rate of 90-day readmission among patients with SCAD. In most of these cases, patients were readmitted within the first 30 days. This is a novel finding which has not been previously reported. Previous reports showed readmission rates ranging 10% to 20% in first 30 days of discharge after different forms of ACS.[17−19] In Alberta Provincial Project for

Table 1
Baseline characteristics of 90-day readmission in SCAD patients

Variable	90-day readmission		Overall	p value
	No	Yes		
Primary admission	8,804 (78.4%)	2,424 (21.6%)	11,228 (100%)	
Age (years)				<0.001
18-49	44.5%	48.9%	45.3%	
50-64	37.5%	32.8%	36.5%	
>65	18%	18.3%	18.2%	
Male	32.5%	32%	32%	0.03
Female	67.5%	67.9%	68%	
CCI[†]				<0.001
0	14.7%	12.6%	14.3%	
1	41.1%	30.4%	38.8%	
≥2	44.1%	57%	47%	
Obesity*	17%	16.8%	16.9%	0.87
Hypertension*	68.9%	72.9%	69.8%	<0.001
Diabetes Mellitus*	0.18%	0.3%	0.2%	0.20
Chronic pulmonary disease*	16.5%	24.7%	18.3%	<0.001
Peripheral vascular disease*	14.2%	18.7%	15.2%	<0.001
Heart Failure*	2.1%	3.1%	3%	
Neurological disorder or paralysis*	1.4%	1.5%	1.4%	0.61
Anemia*	11.9%	17.1%	13%	<0.001
Rheumatoid arthritis and other collagen vascular diseases*	2.8%	3.1%	2.9%	0.40
Weight loss*	2.4%	3%	2.5%	0.05
Median household income category for patients' zip code[‡] (Percentile)				0.01
0-25th	24.3%	27.3%	25%	
26-50th	28.2%	28.7%	28.3%	
51-75th	25.4%	23.7%	25.1%	
76-100th	22.1%	20.3%	21.7%	
Primary payer				<0.001
Medicare/Medicaid	55.4%	65.5%	57.6%	
Private including HMO[¶]	35.2%	27.9%	33.6%	
Self-pay/no charge/other	9.4%	6.5%	8.8%	
Hospital bed size[§]				0.03
Small	9.6%	8.3%	9.3%	
Medium	21.7%	20.3%	21.4%	
Large	68.7%	71.4%	69.3%	
Hospital teaching status				0.01
Nonteaching	32.5%	35.5%	33.2%	
Teaching	67.5%	64.5%	66.8%	
Admission type				0.04
Nonelective	76.4%	75.7%	76.3%	
Elective	23.6%	24.3%	23.7%	
Admission day				0.97
Weekdays	81.8%	81.8%	81.8%	
Weekend	18.2%	18.1%	18.2%	
Disposition				<0.001
Home	85.1%	85.7%	85.2%	
Facility	7%	13.7%	8.5%	
Ohers	7.94%	0.5%	6.3%	
In hospital Mortality	7.65%	0	6%	<0.001
Length of stay (days) (mean ± SE)	5.22± 0.1	5.52± 0.1	5.33±0.1	<0.001

* Variables are AHRQ co-morbidity (cm_) measures.
[†] Charlson/Deyo Co-morbidity index (CCI) was calculated as per Deyo classification.
[‡] Represents 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. http://www.hcupus.ahrq.gov/db/vars/zipinc_qrtl/nisnote.jsp.
[§] The bed size cut-off 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. *State and County QuickFacts*. Washington, DC: US Census Bureau; 2012.
[¶] HMO = Health Maintenance Organization.

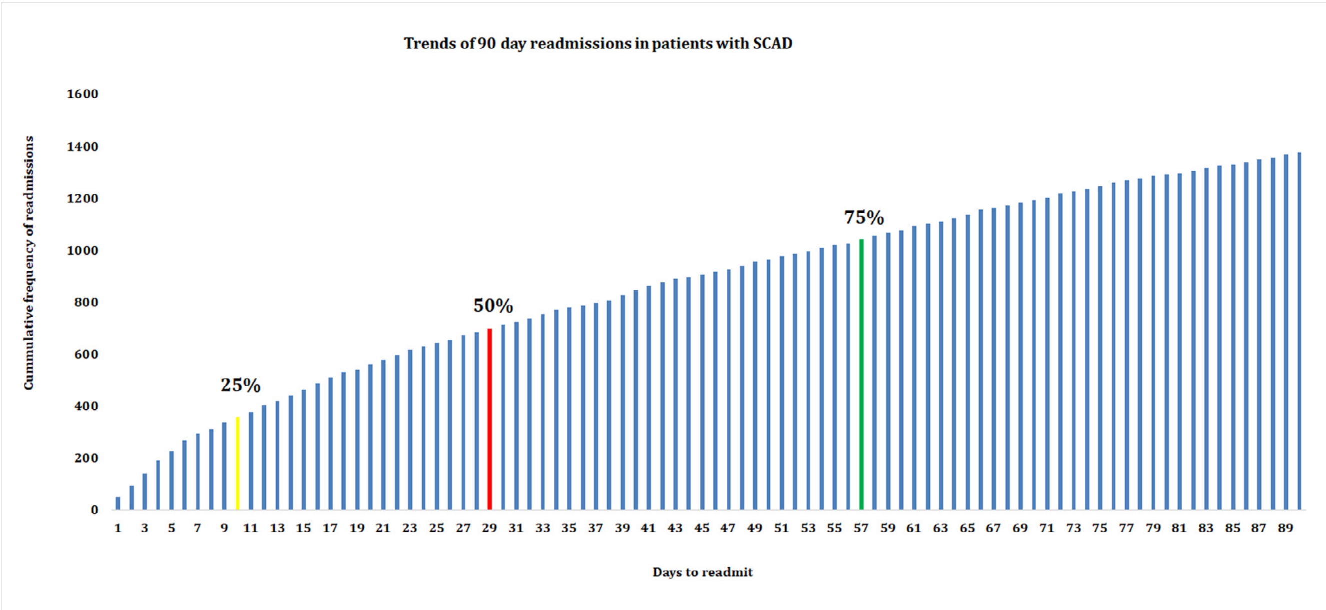

Figure 1. Trends of 90 days readmission in spontaneous coronary artery dissection patients after index hospitalization.

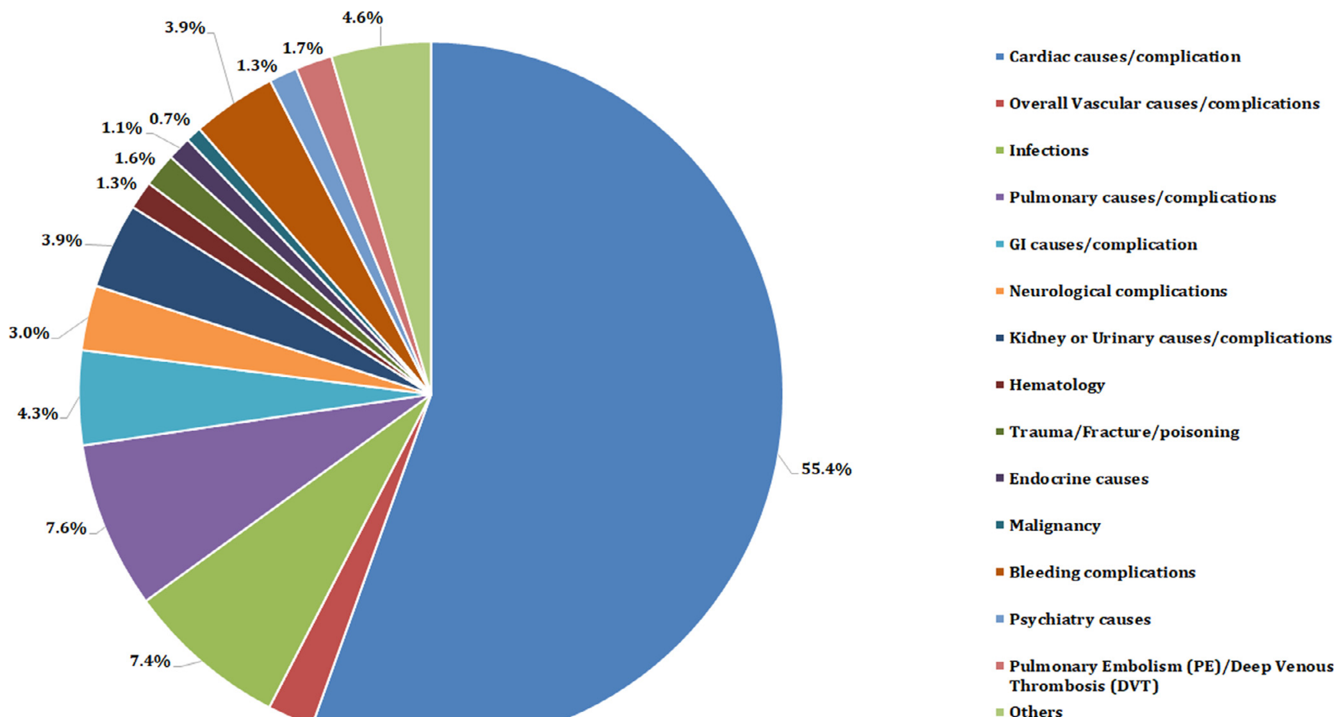

Figure 2. Primary etiologies of 90 days readmission in spontaneous coronary artery dissection patients.

Outcomes Assessment in Coronary Heart Disease registry, out of 3,411 ACS patients, 34.3% patients had more than 1 readmissions in 30 days and readmission rate increased to 61% within a year of ACS discharge.[20] In a prospective evaluation, 0.3% with stable angina, 2.9% with acute myocardial Infarction, and 4.2% of patients with post myocardial infarction angina had SCAD.[21] This disease has predilection to develop ACS in young, apparently healthy women. In our analysis, most of the patients were younger and two-thirds were women. Recently, a contemporary case series showed the prevalence of SCAD in the range of 22% to 35% in women <50 years of age, with the major disease burden concentrated in middle-aged women.[22] Risk factors for SCAD have been extensively studied.[23] In our study, majority of readmitted patients had hypertension (68%) and anemia (12%). This supports the theory that uncontrolled blood pressure and a high flow state from anemia could results in increased wall stress subsequently causing SCAD. Diabetes mellitus (38%) and PAD (14%) were prevalent in our patient population, challenging the notion that SCAD patients have less risk factors for atherosclerosis in comparison to patients who develop obstructive coronary artery disease.

Table 2
Multivariate predictors of 90-day readmission in SCAD patients

Variable	90-day readmission			
	Odds ratio	95% CI		p value
		LL	UL	
Age (years)				
18-49	Referent	Referent	Referent	
50-64	0.90	0.72	1.12	0.339
>65	0.75	0.58	0.96	0.022
Female	1.01	0.87	1.17	0.914
Hypertension*	1.19	1.01	1.41	0.04
Diabetes Mellitus*	0.94	0.28	3.19	0.92
Peripheral Vascular Disease*	1.38	1.14	1.68	0.001
Chronic Pulmonary Disease*	1.35	1.13	1.62	0.001
Anemia*	1.15	0.94	1.42	0.172
Congestive Heart Failure*	1.13	0.71	1.82	0.609
Median household income category for patient's zip code[‡] (Percentile)				
0-25th	Referent	Referent	Referent	
26-50th	0.91	0.75	1.11	0.372
51-75th	0.83	0.68	1.02	0.080
76-100th	0.85	0.69	1.05	0.126
Primary Payer				
Medicare/Medicaid	Referent	Referent	Referent	
Private including HMO[§]	0.69	0.57	0.84	<0.001
Self-pay/no charge/other	0.50	0.36	0.69	<0.001
Hospital Bed Size[†]				
Small	Referent	Referent	Referent	
Medium	1.05	0.77	1.42	0.778
Large	1.22	0.92	1.60	0.161
Hospital teaching status				
Nonteaching	Referent	Referent	Referent	
Teaching	1.02	0.84	1.23	0.866
Disposition				
Home	Referent	Referent	Referent	
Facility/others	1.58	1.24	2.03	<0.001
Length of stay during index hospitalization	1.01	1.00	1.02	0.023

CI = confidence interval; UL = upper limit; LL = lower limit.
* Variables are AHRQ co-morbidity (cm_) measures.
† The bed size cut-off 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. *State and County QuickFacts*. Washington, DC: US Census Bureau; 2012.
‡ Represents 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. http://www.hcupus.ahrq.gov/db/vars/zipinc_qrtl/nisnote.jsp
§ HMO = Health Maintenance Organization.

We found ACS and HF to be the most common causes for readmission among patients with SCAD. In fact, these 2 clinical conditions were responsible for 80% of all readmissions. Given equipoise regarding the correct management of symptomatic patients presenting with SCAD, a significant proportion of these patients are managed conservatively.[23] It is therefore feasible that occurrence of ACS and/or HF symptoms after index hospitalization for SCAD may be attributed to either extension or recurrence of coronary dissection. This mechanism is corroborated by previous studies which reported rates SCAD recurrence in as many as 30% of all patients who initially presented with ACS.[24]

Length of hospital stay was identified as an independent predictor of 90-day readmission. This is an expected finding as longer LOS is likely a marker of a sicker patient cohort with a more complex hospital course. Just as in our SCAD patients, hospital stay ≥5 days has also been shown to be a predictor of 30-day readmission among a large cohort of patients presenting with NSTEMI.[17] Length of stay in SCAD patients (5.3 days) was slightly longer than the hospital stays in patients with stable coronary artery disease after a nonfatal event (4.6 days).[25] Likewise, history of COPD, PAD, and hypertension was found to independently predict the risk of readmission in SCAD patients. Although the exact mechanism is not known, these co-morbidities likely also identify an overall sicker patient cohort which is at risk of complications after index hospitalization.

The final finding of our study was that several factors (specifically age >65, female gender, discharge to a facility, and an increased LOS) predicted increased healthcare costs related to SCAD readmissions. This subgroup of patients

Table 3
Multivariate predictors of increased cost during index hospitalization in SCAD patients

Variable	90-day readmission			
	Odds ratio	95% CI		p value
		LL	UL	
Age (years)				
18-49	Referent	Referent	Referent	
50-64	−0.71	−2.34	0.92	0.393
>65	4.48	2.11	6.84	0.001
Female	2.51	1.41	3.61	<0.001
Hypertension*	−0.03	−1.24	1.19	0.965
Diabetes Mellitus*	−3.65	−13.80	6.51	0.482
Peripheral Vascular Disease*	0.98	−0.61	2.57	0.227
Chronic Pulmonary Disease*	−0.94	−2.36	0.48	0.196
Anemia*	0.54	−1.12	2.20	0.525
Congestive Heart Failure*	−2.40	−6.37	1.57	0.235
Median household income category for patient's zip code‡ (Percentile)				
0-25th	Referent	Referent	Referent	
26-50th	0.94	−0.58	2.47	0.225
51-75th	2.44	0.85	4.04	0.003
76-100th	4.96	3.21	6.72	<0.001
Primary Payer				
Medicare/Medicaid	Referent	Referent	Referent	
Private including HMO§	0.64	−0.85	2.12	0.400
Self-pay/no charge/other	−1.77	−3.93	0.40	0.110
Hospital Bed Size†				
Small	Referent	Referent	Referent	
Medium	−2.00	−5.05	1.05	0.200
Large	−2.59	−5.36	0.18	0.067
Admission day				
Weekdays	Referent	Referent	Referent	
Weekends	−0.60	−2.02	0.83	0.412
Admission Type				
Non Elective	Referent	Referent	Referent	
Elective	1.92	0.56	3.27	0.006
Disposition				
Home	Referent	Referent	Referent	
Facility/others	1.58	3.22	7.41	<0.001
Length of stay during index hospitalization	1.01	3.11	3.30	<0.001

CI = confidence interval; UL = upper limit; LL = lower limit.

* Variables are AHRQ co-morbidity (cm_) measures.

† The bed size cut-off 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. *State and County QuickFacts*. Washington, DC: US Census Bureau; 2012.

‡ Represents 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. http://www.hcupus.ahrq.gov/db/vars/zipinc_qrtl/nisnote.jsp.

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represents sicker cohort thus this prediction model could be useful in allocating resources promptly.

Limitations

The data for our study were derived from an inpatient database and therefore relies on the accuracy and completion of diagnostic codes; our analysis is thus subject to misclassification bias. We could not control for other factors (such as compliance with medications: dual antiplatelet therapy, β blockers and Acetylcholinesterase (ACE) inhibitors; dietary compliance; volume status; severity of patient's pre-existing co-morbidities) which are not tracked in NRD but may potentially affect patients' prognosis after hospital discharge. Finally, the details regarding patient management during the index hospitalization and its effect on readmission rates were not analyzed. However, we believe that the large sample size, consistent results with previous studies, and the lack of selection bias at least partially counterbalance these inherent limitations.

In conclusion, our study of patients with SCAD, we found that one fifth of all discharged patients diagnosed with SCAD on an index hospitalization were readmitted in the first 90 days post discharge. The most common reasons for readmission included ACS, HF, and acute respiratory failure. Independent predictors of 90-day readmission included hypertension, COPD, PAD, and increased LOS. Furthermore, female gender, older age, increased LOS, and discharge to a facility also predictor an increase in healthcare-related cost.

Disclosures

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