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M. C. Tan

Y. H. Yeo

Q. X. Ang

Justin Z. Lee

Eric H. Yang

See next page for additional authors

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Original Research

Hospital Outcomes of Spontaneous Coronary Artery Dissection With Concurrent Ventricular Arrhythmias

Min Choon Tan, MD [a,b], Yong Hao Yeo, MBBS [c], Qi Xuan Ang, MBBS [d], Justin Z. Lee, MD [e], Eric H. Yang, MD [a], Joanne K. Mazzarelli, MD [f], JR Exequiel Pineda, MD [g], Wilber Su, MD [g], Kwan S. Lee, MD [a,*]

[a] *Department of Cardiovascular Medicine, Mayo Clinic, Phoenix, Arizona;* [b] *Department of Internal Medicine, New York Medical College at Saint Michael's Medical Center, Newark, New Jersey;* [c] *Department of Internal Medicine/Pediatrics, Beaumont Health, Royal Oak, Michigan;* [d] *Department of Internal Medicine, Sparrow Health System and Michigan State University, East Lansing, Michigan;* [e] *Department of Cardiovascular Medicine, Cleveland Clinic, Cleveland, Ohio;* [f] *Department of Cardiovascular Medicine, Cooper University Health System/Cooper Medical School of Rowan University, Camden, New Jersey;* [g] *Department of Cardiovascular Medicine, Banner University Medical Center, Tucson, Arizona*

ABSTRACT

Background: While patients with spontaneous coronary artery dissection (SCAD) occasionally present with concurrent ventricular arrhythmias (VA), the impact of VA on in-hospital outcomes in the United States (US) is not well-established. This study aims to analyze in-hospital outcomes of patients with SCAD and concurrent VA and to determine the factors associated with VA occurrence in this high-risk population in the US.

Methods: Using the Nationwide Readmissions Database, our study included patients age 18 years or older who had SCAD between 2017 and 2020. We categorized the cohort into 2 groups depending on the presence of VA during hospitalization. In-hospital outcomes were assessed between SCAD patients with VA and those without. Weighted analysis was performed. We analyzed the independent factors associated with VA occurring among SCAD patients through univariable and multivariable analyses.

Results: Eight hundred seventy-seven SCAD patients were included in the study: 118 (13.5%) with VA and 759 (86.6%) without. SCAD patients with concurrent VA were associated with higher rates of early mortality (10.2% vs 2.0%; $P < .01$), prolonged index hospital stay (≥7 days) (33.1% vs 11.7%; $P < .01$), and non-home discharge (21.2% vs 5.9%; $P < .01$). The length of hospital stay was longer in the SCAD with concurrent VA group (7.39 days vs 3.58 days; $P < .01$), and the median cumulative cost of hospitalization was also higher in this group ($31,451 vs $13,802; $P < .01$). SCAD patients with concurrent VA had increased in-hospital adverse events: acute heart failure, cardiac arrest, cardiogenic shock, cerebral infarction, pulmonary edema, and acute kidney injury. In multivariable analysis, the independent factors associated with VA occurrence among SCAD patients were chronic liver disease (aOR, 3.42; 95% CI, 1.43-8.20; $P < .01$) and heart failure (aOR, 5.63; 95% CI, 3.36-9.42; $P < .01$).

Conclusions: Concurrence of VA among SCAD patients was associated with poorer in-hospital outcomes. Heart failure and chronic liver disease were the independent factors associated with VA occurrence in SCAD patients.

Introduction

Spontaneous coronary artery dissection (SCAD) is characterized by the formation of intramural hematoma in coronary arteries.[1] While the exact mechanism contributing to the intramural hematoma is unknown, it is thought to be due to spontaneous intimal tearing in the arterial wall or disruption of the vasa vasorum of the coronary adventitia, which leads to blood pooling in the intramural space.[2,3] It is estimated to occur in up to 4% of patients presenting with acute coronary syndrome and has been associated with worse outcomes than those without SCAD.[4,5] SCAD is occasionally further complicated by concurrent ventricular arrhythmias (VA), with an incidence of 3% to 12%.[6–9] The outcomes of SCAD complicated with VA have been reported in a retrospective study by Cheung et al based on a Canadian registry.[8] However, data on hospital outcomes of SCAD patients with concurrent VA are not well-established in large-scale studies in the United States (US).

Therefore, we conducted a nationwide retrospective study to assess the in-hospital outcomes of patients with SCAD and concurrent VA in

Abbreviations: AHRQ, Agency for Healthcare Research and Quality; HCUP, Healthcare Cost and Utilization Project; NRD, National Readmission Database; SCAD, spontaneous coronary artery dissection; VA, ventricular arrhythmias.

Keywords: hospital outcome; mortality; spontaneous coronary artery dissection; ventricular arrhythmias.

* Corresponding author: Lee.kwan@mayo.edu (K.S. Lee).

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the US and to determine the independent factors associated with VA occurrence in this high-risk population.

Methods

Data source

The data were obtained from the National Readmission Database (NRD) derived from the Healthcare Cost and Utilization Project (HCUP) State Inpatient Databases. HCUP is sponsored by the Agency for Healthcare Research and Quality (AHRQ). The NRD is one of the nation's largest publicly available all-payer inpatient care databases. It is an annual database that includes approximately 17 million discharges yearly from 2017 to 2020. It can reliably track patient admissions to any hospital in the same state over a year using verified patient linkage numbers. Based on the International Classification of Diseases, Tenth Revision, and Clinical Modification (ICD-10-CM) codes, the patient's diagnoses and procedures during each admission were recorded. We queried this database using ICD-10-CM codes to identify the patient demographic characteristics, the health care facility variables, and the in-hospital outcomes of each admission. Because NRD is publicly available and deidentified, our study did not require institutional review board review approval or informed consent.

Study population

Using ICD-10-CM, we searched for all patients 18 years of age or above with a primary diagnosis of coronary artery dissection (I25.42) during hospitalizations from January to November for each calendar year 2017 to 2020. Notably, no specific ICD code exists yet for SCAD. We, therefore, added several exclusion criteria to ensure that patients in whom coronary artery dissection was not spontaneous were excluded. Coronary artery dissection due to iatrogenic cause (I97.51) was excluded to ensure a homogenous study population of SCAD. In addition, we also excluded patients with a history of myocardial infarction, cerebrovascular accident/transient ischemic attack, prior percutaneous coronary intervention, or prior coronary artery bypass graft to eliminate hospitalizations related to atherosclerotic coronary artery dissection. The study cohort was further categorized into 2 groups based on the occurrence of VA (ICD-10 I47.2 ventricular tachycardia and I49.01 ventricular fibrillation) during hospitalization. Patients with missing data for in-hospital mortality and length of stay were also excluded. As the NRD is constructed using a calendar year of discharge data that does not track the patients between the years, index admissions from December were excluded, given that the 30-day follow-up after discharge would not be available.

Study end points

The primary end point of our study was the in-hospital outcomes of SCAD patients with and without concurrent VA. The hospital outcomes included length of hospital stay, discharge disposition, cost of hospitalization, readmission within 30 days of index hospital stay, and early mortality (a combination of the mortality during index admission and readmission within 30 days of index hospital stay). The in-hospital adverse events included any development of acute heart failure, cardiac arrest, cardiac tamponade, cardiogenic shock, hemopericardium, cerebral infarction, pulmonary edema, venous thromboembolism, and acute kidney injury. For readmission, the number of days from the discharge of index hospitalization to the readmission was used to define the time of readmission. If there were multiple readmissions within 30 days after discharge from index hospitalization, only the first readmission was included for analysis. Same-day transfers within the same hospital or between hospitals are not considered readmissions. The secondary end point of our study was to determine independent factors associated with VA occurrence among SCAD patients.

Definition of clinical variables

Patient-level and hospital-level variables, including age, sex, hospital characteristics, and patient characteristics (median household income based on zip code, primary payer, and discharge disposition), were derived from NRD variables. Patient comorbidity diagnoses were identified by ICD-10-CM codes**.** Acute heart failure was defined as acute or acute on chronic systolic heart failure, acute or acute on chronic diastolic heart failure, and acute or acute on chronic combined systolic and diastolic heart failure. Heart failure as a comorbidity was analyzed via AHRQ-assigned comorbidity measures that include cardiomyopathy, chronic heart failure, rheumatic heart disease, etc. The cost of hospitalization is calculated by adjusting the charge of each hospitalization to the cost-to-charge ratio provided by HCUP. We defined the cumulative cost of hospitalization as the sum of the cost of index hospitalization and the first 30-day readmission after the index hospital stay.

Statistical analysis

Continuous data were summarized as mean with standard deviation or median with interquartile range (Q1, Q3) depending on its distribution; differences between groups were tested using Wilcoxon rank sum tests. Categorical data were summarized as counts and percentages; differences between groups were tested using Pearson's χ^2 squared test. All tests were 2-sided with P values $\leq$.05, indicating statistical significance. Statistical analyses were conducted using Stata version 12.1 (Stata Corporation). All variables in Table 1 were analyzed based on the outcomes using weighted univariable analyses, followed by weighted multivariable logistic regression (the variables with P value $<$.1 were included for multivariable analysis) by taking into account the cluster, strata, and weighting design of NRD. The receiver operating characteristic curve was plotted to measure the area under the receiver operating characteristic curve for the assessment of the accuracy of our multivariable model.

Results

Study population

Our study included 877 patients who had SCAD between January and November for calendar years 2017 to 2020. One hundred eighteen (13.5%) patients (52.61 $\pm$ 13.83 years of age, 69.5% female) had concurrent VA (56 ventricular tachycardia, 42 ventricular fibrillation, and 20 ventricular tachycardia and ventricular fibrillation) during hospitalization, and 759 (86.6%) patients (51.98 $\pm$ 12.71 years of age, 79.7% female) did not have concurrent VA (unweighted), which represented national estimates of 213 (13.7%) patients (53.08 $\pm$ 13.91 years of age, 68.4% female) with SCAD and concurrent VA and 1343 (86.3%) patients (51.69 $\pm$ 12.74 years of age, 79.9% female) with SCAD but no concurrent VA (weighted). Table 1 shows the patient baseline characteristics and hospital characteristics of both groups before and after adjustment. The SCAD patients with concurrent VA had a higher prevalence of chronic liver disease, coagulation disorder, and heart failure.

In-hospital outcomes and cost of hospitalization

The in-hospital outcomes between SCAD patients with and without concurrent VA are depicted in Figure 1. The SCAD patients with concurrent VA had higher rates of prolonged index hospital stay ($\geq$7 days) (33.1% vs 11.7%; $P < .01$), nonhome discharge (21.2% vs 5.9%; $P < .01$), and

Table 1. Baseline patient and hospital characteristics for spontaneous coronary artery dissection (SCAD) patients with and without concurrent ventricular arrhythmias (VA) (before and after weighting adjustment)

	Before adjustment			After adjustment		
	SCAD with concurrent VA	SCAD without concurrent VA	*P* value	SCAD with concurrent VA	SCAD without concurrent VA	*P* value
No. of admissions	118 (13.5%)	759 (86.6%)		213 (13.7%)	1343 (86.3%)	
Baseline characteristics						
Age, y	52.61 ± 13.83	51.98 ± 12.71	.58	53.08 ± 13.91	51.69 ± 12.74	.44
Female sex	82 (69.5%)	605 (79.7%)	.01	146 (68.4%)	1072 (79.9%)	.03
Chronic kidney disease	11 (9.3%)	44 (5.8%)	.14	20 (9.6%)	77 (5.8%)	.17
Chronic liver disease	19 (16.1%)	27 (3.6%)	<.01	36 (17.0%)	50 (3.7%)	<.01
Chronic pulmonary disease	19 (16.1%)	101 (13.3%)	.41	45 (21.0%)	183 (13.6%)	.11
Coagulation disorder	16 (13.6%)	47 (6.2%)	<.01	34 (16.1%)	82 (6.1%)	<.01
Diabetes mellitus	14 (11.9%)	82 (10.8%)	.73	22 (10.3%)	150 (11.2%)	.80
Heart failure	35 (29.7%)	64 (8.4%)	<.01	69 (32.4%)	104 (7.7%)	<.01
Systolic heart failure	32 (27.1%)	45 (5.9%)	.02	58 (27.2%)	72 (5.4%)	.03
Diastolic heart failure	<10 (2.5%)	19 (2.5%)		11 (2.5%)	32 (2.3%)	
Hyperlipidemia	53 (44.9%)	324 (42.7%)	.65	100 (46.8%)	564 (42.0%)	.46
Hypertension	68 (57.6%)	408 (53.8%)	.43	131 (61.3%)	720 (53.6%)	.18
Obesity	29 (24.6%)	185 (24.4%)	.96	53 (24.9%)	339 (25.3%)	.95
Peripheral arterial disease	<10 (6.8%)	40 (5.3%)	.50	19 (8.7%)	72 (5.3%)	.35
Smoking	41 (34.8%)	248 (32.7%)	.66	77 (36.2%)	447 (33.3%)	.64
Valvular heart disease	13 (11.0%)	61 (8.0%)	.28	22 (10.3%)	117 (8.7%)	.64
Elixhauser comorbidity score			<.01			<.01
<4	48 (40.7%)	592 (78.0%)		79 (37.3%)	1041 (77.6%)	
≥4	70 (59.3%)	167 (22.0%)		134 (62.7%)	301(22.4%)	
Charlson comorbidity index			<.01			<.01
0	13 (11.0%)	247 (32.5%)		21 (9.8%)	424 (31.6%)	
1	42 (35.6%)	294 (38.7%)		70 (33.1%)	525 (39.1%)	
≥2	63 (53.4%)	218 (28.7%)		122 (57.1%)	393 (29.3%)	
Hospital variables						
Median household income			.61			.81
First quartile	25 (21.7%)	151 (20.3%)		48 (23.0%)	279 (21.1%)	
Second quartile	33 (28.7%)	177 (23.8%)		61(29.4%)	337 (25.5%)	
Third quartile	25 (21.7%)	184 (24.7%)		44(21.2%)	331 (25.1%)	
Fourth quartile	32 (27.8%)	232 (31.2%)		55 (26.5%)	373 (28.2%)	
Primary payer			.18			.21
Medicare	30 (25.4%)	135 (17.8%)		59 (27.5%)	235 (17.5%)	
Medicaid	12 (10.2%)	112 (14.8%)		23 (10.6%)	183 (13.7%)	
Private including HMO	68 (57.6%)	453 (59.7%)		119 (55.7%)	817 (60.9%)	
Self-pay/no charge/others	<10 (6.8%)	59 (7.8%)		13 (6.2%)	106 (7.9%)	
Hospital Size			.97			.79
Small	15 (12.7%)	90 (11.9%)		30 (13.9%)	156 (11.6%)	
Medium	30 (25.4%)	196 (25.8%)		53 (25.0%)	358 (26.7%)	
Large	73 (61.9%)	473 (62.3%)		130 (61.1%)	828 (61.7%)	
Length of hospital stay after procedure, d	7.39 ± 8.38	3.58 ± 3.95	<.01	7.77 ± 8.83)	3.60 ± 4.01	<.01
Prolonged index hospital stay (≥7 d)	39 (33.1%)	89 (11.7%)	<.01	72 (33.7%)	158 (11.8%)	<.01
Disposition			<.01			<.01
Home	93 (78.8%)	714 (94.1%)		161 (75.8%)	1263 (94.1%)	
Facilities	12 (10.2%)	17 (2.2%)		26 (12.4%)	31 (2.3%)	
Against medical advice/unknown	13 (11.0%)	28 (3.7%)		25 (11.8%)	49 (3.6%)	
Cumulative cost of hospitalization, $	31,450.62 [52,187.85]	13,802.06 [14,806.98]	<.01	32,295.52 [56,451.55]	13,657.62 [14,406.01]	<.01

Values are n (%), mean ± SD, or median [IQR].
HMO, health maintenance organization.

early mortality (10.2% vs 2.0%; $P < .01$) than those without concurrent VA (Central Illustration). The 30-day readmission rate was 13.2% for the group with concurrent VA compared to 9.5% for the group without concurrent VA ($P = .24$). The mean total length of hospital stay was longer in the group with concurrent VA than those without concurrent VA (7.39 days vs 3.58 days; $P < .01$). The median cumulative cost of hospitalization was also higher in the group with concurrent VA ($31,451 vs $13,802; $P < .01$).

In-hospital adverse events

The in-hospital adverse events between SCAD patients with and without concurrent VA are depicted in Table 2. During hospitalization, SCAD patients with concurrent VA experienced higher rates of acute heart failure (22.0% vs 5.4%; $P < .01$), cardiac arrest (27.1% vs 1.1%; $P < .01$), cardiogenic shock (28.0% vs 5.1%; $P < .01$), cerebral infarction (2.5% vs 0.4%; $P < .01$), pulmonary edema (3.4% vs 0.5%; $P < .01$), and acute kidney injury (19.5% vs 5.8%; $P < .01$) than those without concurrent VA. Additional analysis of hospital outcomes in cardiac arrest and cardiogenic shock events is depicted in Supplemental Tables S1 and S2.

Independent factors associated with VA occurrence among SCAD patients

Table 3 depicts the independent factors associated with VA occurrence using weighted univariable and multivariable analysis. Through univariable analysis, female sex, heart failure, chronic liver disease, and coagulation disorders were independently associated with VA events among SCAD patients. Further analysis was performed using a

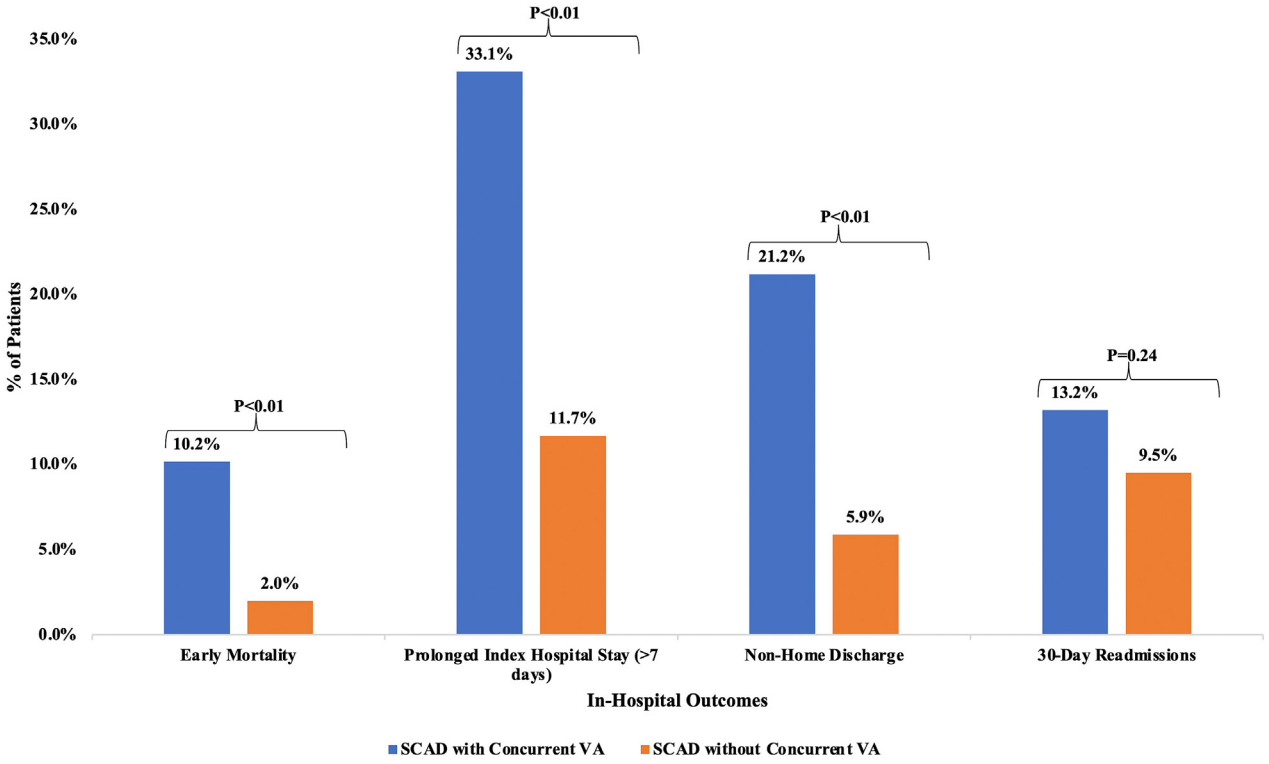


Figure 1.
In-hospital outcomes of spontaneous coronary artery dissection patients with and without concurrent ventricular arrhythmias.

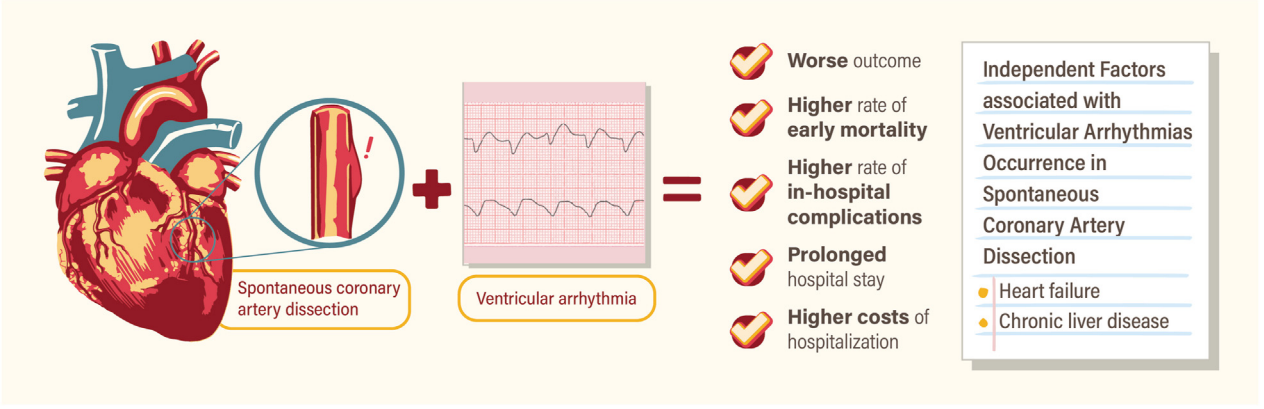
multivariable regression model and revealed that the independent factors significantly associated with VA were chronic liver disease (adjusted odds ratio [aOR], 3.42; 95% CI, 1.43-8.20; $P < .01$) and heart failure (aOR, 5.63; CI, 3.36-9.42; $P < .01$). The area under the receiver operating characteristic curve of this analysis was 0.733.

Discussion

This is the largest all-payer data in the US from a nationwide readmission database on in-hospital outcomes of SCAD patients with concurrent VA. Our analysis of 877 patients with SCAD showed that: (1) 13.5% of patients with SCAD had developed concurrent VA during hospitalization; (2) SCAD patients with concurrent VA were associated with poorer in-hospital outcomes in terms of in-hospital adverse events, early mortality, prolonged hospital stays, nonhome discharge, and hospitalization cost; (3) heart failure and chronic liver disease were independent factors associated with VA occurrence among patients with SCAD.

Our study showed that 13.5% of the patients with SCAD had concurrent VA. This finding is slightly higher than the existing published results of 3% to 12%.[6–9] A community-based study of 349 SCAD patients reported an incidence rate of 5.7%.[7] Another study based on Canadian SCAD registries showed that 8.0% of SCAD patients had concurrent VA.[8] A cohort study based on 4 Arab Gulf countries reported a similar incidence rate of VA as ours at 12.0%.[9]

Our study revealed that SCAD patients with concurrent VA had worse in-hospital adverse events. Unfortunately, the lack of echocardiography and angiography data in our database limited the effort to assess the ischemic burden among these patients. The percentage of SCAD patients with VA in our study having these cardiac adverse events



Central Illustration.
Hospital outcomes among spontaneous coronary artery dissection patients with concurrent ventricular arrhythmias and independent factors associated with ventricular arrhythmia occurrence.

Table 2. In-hospital adverse events for spontaneous coronary artery dissection (SCAD) patients with and without concurrent ventricular arrhythmias (VA).

In-hospital adverse events	SCAD with concurrent VA (n = 118)	SCAD without concurrent VA (n = 759)	*P* value
Acute heart failure	22.0%	5.4%	<.01
Cardiac arrest	27.1%	1.1%	<.01
Cardiac tamponade	1.7%	0.4%	.08
Cardiogenic shock	28.0%	5.1%	<.01
Cerebral infarction	2.5%	0.4%	<.01
Pulmonary edema	3.4%	0.5%	<.01
Venous thromboembolism	3.4%	1.2%	.07
Acute kidney injury	19.5%	5.8%	<.01

was 4 to 6 folds more than those without VA. A similar result is seen in the study of 83 SCAD patients by Daoulah et al.[9] While the exact mechanism is unclear, catecholamine surge and automatic mechanisms among SCAD patients have been postulated as the underlying mechanisms of VA.[9]

Our study's overall early mortality rate for patients with SCAD, regardless of their VA status, was 3.1%. This is consistent with the existing literature, which showed in-hospital mortality <5.0%.[2] Our study also indicated that SCAD patients with concurrent VA had higher risks of early mortality. This finding further justifies the current guidelines, which suggest a prolonged period of in-hospital monitoring for SCAD patients with VA to detect the risk of dissection extension and recurrent SCAD.[9,10]

Heart failure is an independent factor associated with VA occurrence among the patients with SCAD in our analysis. This is particularly significant for systolic heart failure, which is 5 times more prevalent among SCAD patients with VA than those without VA. A study by Cheung et al also found that the left ventricular ejection fraction <50% was associated with VA events among SCAD patients. This finding may be explained by the higher burden of arrhythmogenic substrates for VA in patients with heart failure.[11] Interestingly, our study also found chronic liver disease as another independent factor associated with VA occurrence. Chronic liver disease as a comorbidity in our study was analyzed via AHRQ-assigned comorbidity measures. It included a wide array of chronic liver diseases but did not include the ICD-10 codes for abnormal liver function studies (R94.5 and R74.01).

Limitations

Despite routine quality-control measures by HCUP to ensure the data validity and reliability, there are still some limitations in our study. Firstly, similar to the existing studies using coding-based databases, the diagnosis of SCAD in this present study was based on ICD coding for coronary artery dissection. Currently, there are no specific ICD-10 codes for SCAD. Therefore, despite our efforts to exclude those who experienced iatrogenic injury (iatrogenic SCAD) and those who had coronary artery disease history (atherosclerotic SCAD), our study population may still include individuals with mixed nonatherosclerotic SCAD and atherosclerotic coronary artery dissection. Due to the nature of this database, data regarding the type of SCAD and coronary artery involved were not available. Secondly, the out-of-hospital deaths that occurred before readmission are not recorded, limiting our early mortality to in-hospital mortality. Thirdly, the exact timing of VA from SCAD presentation and specific patient variables such as clinical presentation, left ventricular ejection fraction, medications, and management are not available. The temporal relationship between hospital adverse events and VA could not be assessed. These limit our attempts to explore their impact on hospital outcomes. Fourthly, as with most large administrative database studies, the main limitation includes miscoding in primary diagnoses and underreporting of secondary diagnoses. The last limitation of our study is being unable to track the patients admitted in one state and readmitted in another.

Conclusions

Our study demonstrates that SCAD with concurrent VA had poorer in-hospital outcomes in in-hospital adverse events, early mortality, prolonged hospital stays, hospitalization cost, and nonhome discharge. Heart failure and chronic liver disease were independently associated with VA occurrence in SCAD patients. This highlights the importance of closely monitoring and consideration of aggressive VA management among these high-risk patients.

Table 3. Univariable and multivariable analysis of independent factors associated with ventricular arrhythmia occurrence among spontaneous coronary artery dissection patients (after adjustment).

Independent factors	Univariable analysis			Multivariable analysis		
	OR	95% CI	*P* value	OR	95% CI	*P* value
Age	1.01	0.99-1.03	.44	–	–	–
Female sex	0.55	0.31-0.96	.03	0.66	0.37-1.19	.17
Anemia	0.81	0.22-2.95	.75	–	–	–
Chronic kidney disease	1.74	0.78-3.91	.18	–	–	–
Chronic liver disease	5.34	2.39-11.93	<.01	3.42	1.43-8.20	<.01
Chronic pulmonary disease	1.68	0.89-3.16	.11	–	–	–
Coagulation disorder	2.96	1.35-6.50	<.01	1.31	0.56-3.09	.53
Diabetes mellitus	0.91	0.45-1.85	.80	–	–	–
Heart failure	6.35	3.88-10.40	<.01	5.63	3.36-9.42	<.01
Hyperlipidemia	1.21	0.73-2.03	.46	–	–	–
Hypertension	1.37	0.86-2.18	.18	–	–	–
Malignancy	4.58	0.69-30.60	.12	–	–	–
Obesity	0.98	0.56-1.74	.95	–	-	–
Obstructive sleep apnea	1.00	0.43-2.35	1.00	–	–	–
Peripheral arterial disease	1.70	0.55-5.19	.35	–	–	–
Pulmonary hypertension	2.21	0.77-6.36	.14	–	–	–
Smoking	1.14	0.66-1.94	.64	–	–	–
Valvular heart disease	1.20	0.56-2.58	.64	–	–	–

Declaration of competing interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethics statement and patient consent

Because the National Readmission Database is publicly available and deidentified, our study did not require institutional review board review approval or informed consent.

Supplementary material

To access the supplementary material accompanying this article, visit the online version of the Journal of the Society for Cardiovascular Angiography & Interventions at 10.1016/j.jscai.2023.101231.

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