JACC: CARDIOVASCULAR INTERVENTIONS VOL. 9, NO. 17, 2016

ISSN 1936-8798/$36.00
PUBLISHED BY ELSEVIER

Letters

TO THE EDITOR

Catheter-Induced Iatrogenic Coronary Artery Dissection in Patients With Spontaneous Coronary Artery Dissection

Iatrogenic coronary artery dissection (ICAD) during coronary angiography is a rare (<0.2%) (1,2) but potentially fatal complication. ICAD may be particularly problematic in patients with spontaneous coronary artery dissection (SCAD). A high prevalence of predisposing arteropathies, particularly fibromuscular dysplasia (FMD) and other less frequent arteriopathies (3), may impair and weaken the coronary arterial walls rendering them more susceptible to iatrogenic trauma.

We performed a retrospective observational study using patient-level data from the Vancouver General Hospital SCAD registries, approved by the University of British Columbia Research Ethics Board. All patients were followed prospectively at our SCAD clinic or by telephone follow-up. Baseline demographics, coronary angiogram procedural characteristics, revascularization details, and in-hospital and long-term clinical outcomes were recorded for each patient. Coronary angiograms were qualitatively assessed by 2 experienced cardiologists to confirm and classify the SCAD angiographic subtype (4). Procedure-specific characteristic were determined including the use of diagnostic or guiding catheters, type and size (outer diameter) of catheters, presence of deep catheter engagement (>10 mm beyond the coronary ostium), anatomic orientation of coronary ostium (inferior orientation), and vascular access used (radial or femoral). In-hospital and long-term major cardiac adverse events (MACE) of all-cause mortality, cardiac mortality, stroke, reinfarction, cardiogenic shock, congestive heart failure, severe ventricular arrhythmia, repeat revascularization (or unplanned revascularization), and cardiac transplantation were recorded.

Descriptive statistics were used to summarize baseline data. Continuous variables were summarized as mean ± SD or median with corresponding interquartile ranges (IQR). Categorical variables were summarized as frequencies and percentages. For comparison of categorical variables, the Fisher's exact test was used. Statistical testing was performed as 2-sided tests; $p < 0.05$ was considered significant.

We included 211 consecutive prospectively followed nonatherosclerotic SCAD patients in this study who had their index coronary angiograms performed 1999 to 2015. The mean age was 52.3 ± 9.1 years, and the majority were women (91.9%) and Caucasian (81.5%). There was no difference in the baseline demographics of ICAD versus non-ICAD patients. All presented with myocardial infarction (76.3% non-ST-segment elevation and 23.7% ST-segment elevation). Multivessel SCAD occurred in 12.3%. Extracoronary FMD (renal, ileofemoral, or cerebrovascular) was diagnosed in 83.6%. Revascularization was performed in 20.4% (18.5% percutaneous coronary intervention [PCI], 3.3% coronary artery bypass grafting).

There were 348 coronary angiograms performed, including initial and repeat studies. The overall incidence of ICAD was 3.4% (12 of 348); 6 of the 12 occurred during diagnostic angiogram and the other 6 during ad hoc PCI portion of the angiogram. For index angiograms/PCI performed during the acute SCAD event (n = 211), the incidence of ICAD was 4.7% (10 of 211). The incidence of ICAD during diagnostic angiogram only cases was 2.0% (6 of 300), with higher incidence of ICAD during ad hoc PCI cases (14.3%; 6 of 42; $p = 0.001$). No ICAD occurred during follow-up diagnostic angiograms, but there were 2 ICAD on follow-up PCI.

Of the 12 ICAD, 4 involved the left main artery, which extended to left anterior descending and circumflex arteries. One involved only the proximal left anterior descending artery and 7 involved the right coronary artery. The dissections were extensive with mean dissection length 45.6 ± 24.9 mm, with 75% (9 of 12) classified as National Heart, Lung, and Blood Institute type D dissection. When ICAD occurred, PCI was pursued as initial treatment in 11 of the 12 cases; 7 of those 11 had successful procedural outcomes. PCI of the dissected arteries required median 3.5 stents (IQR: 1.5 to 4.5) with total stent length per artery of 47.5 mm (IQR: 47 to 112). Coronary artery bypass grafting was pursued in 3 cases due to failed

JACC: CARDIOVASCULAR INTERVENTIONS VOL. 9, NO. 17, 2016
SEPTEMBER 12, 2016:1851–7

PCI, whereas 1 had coronary artery bypass grafting 8 months later due to severe in-stent restenosis. One ICAD was treated conservatively (isolated ostial right coronary artery dissection). ICAD cases had a greater proportion of guide catheter usage (75.0%; 9 of 12; $p < 0.0001$), including Voda-type guide catheter (33.3% vs. 10.1%; $p = 0.032$). Deep catheter intubation occurred in 66.7% of ICAD cases, compared with 28.0% of non-ICAD cases ($p = 0.007$). In addition, ICAD cases had a greater proportion of radial artery access (50.0%; 6 of 12) compared with non-ICAD cases (16.4%; $p = 0.009$). ICAD cases also had higher prevalence of ad hoc PCI (not as a treatment for ICAD) after diagnostic angiography (50.0%), compared with non-ICAD cases (10.7%; $p = 0.001$).

There was no in-hospital mortality. However, patients with ICAD had significantly higher frequency of in-hospital composite MACE (25.0% vs. 5.5%; $p = 0.036$), primarily driven by in-hospital repeat myocardial infarction (25.0% vs. 3.0%; $p = 0.014$). At a median follow-up of 3.1 years (IQR: 1.9 to 6.5), composite postdischarge MACE remained significantly higher in the ICAD group (41.7% vs. 18.1%; $p = 0.045$). Both repeat myocardial infarction (41.7% vs. 16.6%; $p = 0.044$) and repeat revascularization (50.0% vs. 19.6%; $p = 0.023$) were significantly higher in the ICAD compared with the non-ICAD group. The overall MACE was 66.7% in ICAD and 22.1% in non-ICAD group ($p = 0.002$).

In this study, we retrospectively reviewed the incidence and risk factors for ICAD in SCAD patients. The incidence of ICAD was not rare in SCAD patients (3.4%), which seemed to be much higher than the reported incidence in the general population undergoing coronary angiography (<0.2%). This >17-fold higher incidence of ICAD among SCAD patients highlights the underlying fragility of their coronary arterial wall, which likely reflects their underlying predisposition to spontaneous dissection.

We previously described the prevalence and types of predisposing arteriopathies and precipitating stressors that can elicit SCAD (3). The majority of patients with SCAD (>80%) have ≥1 potential predisposing arteriopathy on screening, with FMD accounting for the majority. FMD-affected arteries have abnormal cellularity and connective tissue structure within the various arterial layers, which can weaken the arterial walls, predisposing not only to spontaneous tears, but also to iatrogenic wall disruption. Similarly, other connective tissue disorders or arteriopathies that weaken the coronary artery architecture can be susceptible to such dissections.

The procedural risks for ICAD make intuitive sense, especially in vessels with abnormal structural integrity. Guide catheters are stiffer and may cause more mechanical trauma to the vessel wall. Deep catheter intubation can traumatize the deep segment of the arterial wall, especially if the catheter tip abuts the arterial wall. In these situations, a forceful contrast injection can further elicit a tear due to high hydraulic pressure. With regard to PCI, the need to advance and retrieve balloon catheters and stents can result in forward catheter migration, which may inadvertently traumatize the vessel wall. Furthermore, PCI requires the use of guide catheters, more frequent catheter manipulation, and at times deeper catheter intubation for greater support. In terms of the radial approach, noncoaxial engagement in the coronary ostium, deep catheter engagement, and frequent need for more aggressive catheter manipulation owing to the upper limb vessel anatomy (subclavian and brachiocephalic tortuosity) may increase the risk of vessel trauma.

These observations are important reminders to angiographers to take particular care when performing angiography and PCI in SCAD patients. Meticulous catheterization techniques should be employed, avoiding deep catheter engagement, noncoaxial positioning of the catheter tip, catheter dampening, and strong contrast injections. Nonselective injections should be considered if ostial dissections are suspected. Our observed high ICAD rates during ad-hoc PCI together with high PCI failure rates with SCAD (3,5), further strengthen the recommendation that a conservative approach is preferred.

In conclusion, ICAD is not infrequent during diagnostic coronary angiography or PCI in SCAD patients. Angiographers/interventionists should be aware of these heightened risks and employ meticulous techniques during angiography of SCAD patients.

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http://dx.doi.org/10.1016/j.jcin.2016.06.026

Please note: Dr. Saw has received research grants for SCAD research (Canadian Institutes of Health Research, University of British Columbia Division of Cardiology, AstraZeneca, Abbott Vascular, St Jude Medical, and Servier); and speaker honorarium for SCAD (AstraZeneca, St Jude Medical, and Sunovion). All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

The authors thank the Vancouver General Hospital Cardiology Research Group (Jackie Chow, Naomi Uchida, Robyn Tkatch) for patient and study coordination.

We also thank Dr. Eve Aymong and the Cardiovascular Imaging Research Core Laboratory (CIRCL, University of British Columbia) for review of coronary angiograms.

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T-Stenting With Small Protrusion

The Default Strategy for Bailout Provisional Stenting?

Data from several randomized trials have indicated that most bifurcation lesions can be appropriately managed by a provisional strategy (1). However, in up to one-third of cases the operator may need to switch to a two stent strategy after main branch stent implantation (1). The T-stenting with small protrusion (TAP) technique ensures complete coverage of the side branch (SB) ostium, causes minimal deformation to the SB stent, and minimizes stent overlap while being relatively less technically demanding. To date, several case series have reported outcomes involving predominantly first-generation stents (2–5). We sought to analyze the outcomes of TAP stenting with second generation drug-eluting stents. Data were examined from 57 de novo bifurcation lesions treated with provisional 2-stenting using second-generation drug-eluting stents at 2 centers in Milan, Italy between December 2007 and June 2015. All patients provided informed consent for both the procedure and subsequent data collection and analysis.

The decision to cross-over from a provisional strategy to a 2-stent strategy was dependent on the following 3 main factors after main branch stenting:

1. A type B or higher dissection in the SB;
2. A reduction in TIMI (Thrombolysis In Myocardial Infarction) flow (<3) in the SB; and
3. A residual stenosis of >70% in the SB.

The primary endpoint measured at follow-up was target lesion failure, defined as composite of cardiac death, myocardial infarction, and target lesion revascularization. In addition, patients were followed for instances of target vessel revascularization and definite stent thrombosis. Myocardial infarction was defined as the presence of pathologic and new Q waves on an electrocardiogram, or an increase in creatinine kinase-myocardial band level to >5× the upper limit of the normal range. **Table 1** depicts the baseline characteristics of the patients. The mean age of patients was 66.5 ± 10.0 years; 75.4% were male and 21.1% diabetic. The mean ejection fraction of

TABLE 1 Patient and Procedural Characteristics

Age (yrs)	66.5 ± 10.0
Male	43 (75.4)
Diabetes mellitus	12 (21.1)
Insulin dependent	3 (5.3)
Dyslipidemia	31 (54.4)
Hypertension	38 (66.7)
Current smoker	7 (12.3)
LVEF (%)	53.4 ± 10.5
Previous MI	17 (29.8)
Previous PCI	27 (47.4)
Previous CABG	2 (3.5)
Family history of CAD	24 (42.1)
SYNTAX score	23.2 ± 11.3
PCI in setting of	
ACS	8 (14)
Stable	49 (86)
Site of bifurcation	
LAD/diagonal	35 (61.4)
LCx/OM	9 (15.8)
Distal left main	11 (19.3)
RCA/PDA	2 (3.5)
True bifurcation	48 (84.2)
ACC/AHA class B2/C	37 (64.9)
Main branch	
Stent diameter (mm)	3.1 ± 0.42
Number of stents	1.53 ± 0.83
Total stent length (mm)	34.9 ± 18.0
Maximum dilation pressure (atm)	19 ± 5.30
Side branch	
Stent diameter (mm)	2.6 ± 0.36
Number of stents	1.16 ± 0.37
Total stent length (mm)	19.2 ± 10.8
Maximum dilation pressure (atm)	15.2 ± 5.33
Type of DES	
Everolimus	28 (49.1)
Zotarolimus	9 (15.8)
Sirolimus	6 (10.5)
Biolimus	12 (21.1)
Amphilimus	2 (3.5)

Values are mean ± SD or n (%).

ACC/AHA = American College of Cardiology/American Heart Association; ACS = acute coronary syndrome(s); CABG = coronary artery bypass grafting; CAD = coronary artery disease; LAD = left anterior descending artery; LCx = left circumflex artery; LVEF = left ventricular ejection fraction; MI = myocardial infarction; OM = obtuse marginal; PCI = percutaneous coronary intervention; PDA = posterior descending artery; RCA = right coronary artery.