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EDITORIAL COMMENT: Expert Article Analysis for:
The disasters we create: Iatrogenic catheter-induced ostial coronary artery dissection

Iatrogenic catheter-induced ostial coronary artery dissections: Prevalence, management, and mortality from a cohort of 55,968 patients over 10 years

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Abstract

Objective: We sought to describe the prevalence, management strategies and evaluate the prognosis of patients with iatrogenic catheter-induced ostial coronary artery dissection (ICOCAD).

Background: ICOCAD is a rare but potentially devastating complication of cardiac catheterisation. The clinical manifestations of ICOCAD vary from asymptomatic angiographic findings to abrupt vessel closure leading to myocardial infarction and death.

Methods: 55,968 patients who underwent coronary angiography over a 10-year period were screened for ICOCAD as defined by the National Heart, Lung, and Blood Institute. The management and all-cause mortality were retrieved from local and national databases.

Results: The overall prevalence of ICOCAD was 0.09% (51/55,968 patients). Guide catheters accounted for 75% (n = 37) of cases. Half of the ICOCAD cases involved the right coronary artery while the remaining were related to left main stem (23/51; 45%) and left internal mammary artery (2/51; 4%). Two-thirds of ICOCAD were high grade (type D, E, and F). The majority of cases were type F dissections (n = 18; 66%), of which two third occurred in females in their 60s. The majority of ICOCAD patients (42/51; 82%) were treated with percutaneous coronary intervention while the remaining underwent coronary artery bypass grafting (3/51; 6%) or managed conservatively (6/51; 12%). Three deaths occurred during the index admission while 48/51 patients (94.1%) were safely discharged without further mortality over a median follow-up of 3.6 years.

Conclusions: ICOCAD is a rare but life-threatening complication of coronary angiography. Timely recognition and prompt bailout PCI is a safe option for majority of patients with good clinical outcomes.

KEYWORDS
angiography, complications, coronary aneurysm/dissection/perforation, coronary, diagnostic catheterization, percutaneous coronary intervention

1 | INTRODUCTION

Iatrogenic catheter-induced ostial coronary artery dissection (ICOCAD) is a recognized complication of cardiac catheterisation, which can lead to abrupt vessel closure with consequent myocardial infarction and death. ICOCAD refers to diagnostic or guide catheter causing ostial native coronary or graft vessel dissections. Prompt recognition and maintenance of coronary perfusion is key to prevent immediate life-threatening complications. Depending on the severity of the dissection, conservative treatment or revascularisation with bailout percutaneous coronary artery intervention (PCI) or surgery have been described as potential treatment strategies. The aim of this study was to assess the prevalence, describe the management strategies, and evaluate the prognosis of patients with ICOCAD.

2 | METHODS

2.1 | Study design and patient population

This is a retrospective, observational cohort study. The study cohort consisted of all patients with an iatrogenic catheter-induced ostial coronary artery (native and grafts) dissection sustained during coronary angiography at the Barts Health NHS Trust (London, UK) over a 10-year period (August 2008–August 2018). Patients presenting with stable angina, unstable angina, and non-ST-elevation myocardial infarction (NSTEMI) and ST-elevation myocardial infarction (STEMI) were included in the analysis. Patients undergoing elective coronary angiography for assessment of cardiomyopathy, left ventricular systolic dysfunction and valve disease were also included. Patients were not excluded on the basis of indication for coronary angiography. Data analysis was approved by Barts Health NHS Trust Clinical Effectiveness Unit as part of a local audit (ID: 8936). All authors have read and agreed to the manuscript as written.

2.2 | Identification of cases and data collection

The clinical data were prospectively entered into a local database (Centricity until October 2016, followed by iWeb to 2018). The angiogram and procedural reports of patients with coronary dissections were reviewed. Only those with confirmed iatrogenic catheter-induced ostial coronary and graft artery dissections were included in this study. Balloon angioplasty dissections were not considered. For patients undergoing PCI, the data were collected in accordance with the British Cardiovascular Intervention Society (BCIS) standards. Baseline patient characteristics (age, hypertension, hypercholesterolaemia, diabetes mellitus, previous myocardial infection, previous PCI or coronary artery bypass grafting (CABG), left ventricular ejection fraction <30%, chronic kidney disease with eGFR <15 ml/min/1.73 m ̂2) and procedural data (indication for coronary angiography, access route, culprit vessel, type and size of catheter, use of GPIIb/IIIa inhibitors, percutaneous management strategies, and mortality) were collected.

2.3 | Classification of coronary artery dissections

All coronary angiograms were retrospectively reviewed by two interventional cardiologists (A. R. and R. B.) and the coronary artery dissections were classified as types A to F based on the National Heart, Lung and Blood Institute (NHLBI) system developed from the Coronary Angioplasty Registry.[1] In case of a disagreement, a third interventional cardiologist was consulted (C. O. M.). The type of dissection was based on the angiographic appearances of the intimal disruption and contrast clearance:

1. Type A dissections represent radiolucent areas within the coronary lumen during contrast injection, with minimal or no persistence of contrast
2. Type B dissections are parallel tracts or double lumen separated by a radiolucent area during contrast injection, with minimal or no persistence
3. Type C dissections appear as contrast outside the coronary lumen with persistence of contrast in the area after clearance of contrast from the coronary lumen
4. Type D dissections represent spiral luminal filling defects, frequently with extensive contrast staining of the vessel
5. Type E dissections appear as new, persistent filling defects
6. Type F dissections represent those that lead to total occlusion of the coronary artery, without anterograde flow.

2.4 | Treatment of ICOCADs

The management strategy was entirely at the discretion of the treating physician. The ability to perform PCI and cardiothoracic surgery was available on site throughout the study period. The PCI strategy was at the discretion of the operator, including direct stenting, pre- and post-dilatation strategies, use of intravascular imaging devices, and use of pharmacological agents such as Glycoprotein IIb/IIIa inhibitors.

2.5 | Mortality data

All-cause mortality data were recorded as of 2 September 2018 and obtained via the British Cardiovascular Intervention Society (BCIS) national database, part of the National Institute of Cardiovascular Outcomes Research (NICOR). This national database is linked to the UK Office of National Statistics and provides systematically updated live/death status of treated patients. Where this data was not available, local patient health records (Cerner Millenium and EPR) were used to assess mortality.

2.6 | Statistical analysis

Categorical data are summarized using absolute values (percentage). Normally distributed, continuous data are presented as mean ± *SD* or, where skewed, as median (25th–75th percentile). Normally distributed continuous variables were compared using Student *t* tests, and the Mann–Whitney *U* test was used to compare non-normally distributed continuous variables. Categorical data were compared using the Pearson chi-squared test. The follow-up time for each patient was calculated from the date of their ICOCAD to the date of death (all-cause mortality) or to 2 September 2018. The cumulative probability for the occurrence of mortality was estimated using the Kaplan–Meier method. A two-sided $p < .05$ was considered statistically significant. All statistical analyses were performed using Stata11.

3 | RESULTS

3.1 | Baseline and procedural characteristics

During the study period 55,968 patients underwent coronary angiography and ICOCAD occurred in 51 (0.09%; 95% CI 0.06 to 0.11%) patients. The median age of the patients was 65 (55–72) years old and 27 (53%) were male. Twenty-five patients (49%) with ICOCAD were admitted with an acute coronary syndrome while the remaining underwent coronary angiography for assessment and/or treatment of stable coronary artery disease or other elective indications. Multivessel disease was present in 29 patients (56.9%). Baseline patient characteristics are summarized in Table 1. Most procedures complicated by ICOCAD were carried out via the radial approach (n = 39; 76%), commonly using 6F catheters (6F: n = 42 (82%), 5F: n = 5 (9.8%), 7F: n = 2 (3.9%), 8F: n = 2 (3.9%)). Thirty-seven (75%) ostial dissections were caused by a guide catheter and a diagnostic catheter was the culprit in the rest. The catheters and access route used in the 55,917 patients without ICOCAD were not available.

TABLE 1 Baseline demographic characteristics of patients with iatrogenic catheter-induced coronary artery dissection

Characteristics	Patients with iatrogenic catheter-induced ostial coronary artery dissection (n = 51)
Age (years)	65 (55–72)
Male	27 (53%)
Diabetes	13 (25%)
Hypertension	29 (57%)
High cholesterol	30 (59%)
Chronic kidney disease	2 (4%)
LV EF < 30%	3 (6%)
Previous MI	10 (20%)
Previous CABG	6 (12%)
Previous PCI	17 (33%)

Abbreviations: CABG, coronary artery bypass grafting; LVEF, left ventricular ejection fraction; MI, myocardial infarction; PCI, percutaneous coronary artery intervention.

The left main stem (LMS) was dissected in 23 cases (45%), the right coronary artery (RCA) in 26 procedures (50%) and the left internal mammary (LIMA) in two procedures (4%). The catheters involved are shown in Table 2.

The LMS was dissected by diagnostic catheters in 7/23 patients (30%) and guiding catheters were used in 16/23 cases (70%). The most common catheter causing ICOCAD of the LMS was an EBU (EBU 3.5 or EBU 4.0), accounting for 9/23 (39%) of dissections. The catheters involved in LMS ICOCAD are shown in Figure 1(a).

The RCA was dissected by diagnostic catheters in 6/26 patients (23%) and by guiding catheters in 20/26 cases (77%). The most common catheter causing ICOCAD of the RCA was an Amplatz left (AL 0.5 guiding, AL 1.0 guiding and AL 1.0 diagnostic) accounting for 11/26 (42%) of dissections. The catheters involved in RCA ICOCAD are shown in Figure 1(b).

TABLE 2 Catheters involved in ostial coronary dissection

Dissected vessel	Catheter	Frequency	Percent
LMS	EBU3.5 G	7	30.43
	JL3.5	4	17.39
	AL2 G	3	13.04
	JL3.5 G	3	13.04
	EBU4 G	2	8.70
	Tiger	2	8.70
	AL1	1	4.35
	JL4	1	4.35
RCA	AL1 G	8	30.77
	JR4 G	8	30.77
	JR4	4	15.38
	AL0.75 G	2	7.69
	AR1 G	2	7.69
	AL1	1	3.85
	Tiger	1	3.85
LIMA	IMA G	1	50.00
	JR4 G	1	50.00

Note: The suffix "G" denotes a guiding catheter.
Abbreviations: LIMA, left internal mammary artery; LMS, left main stem; RCA, right coronary artery

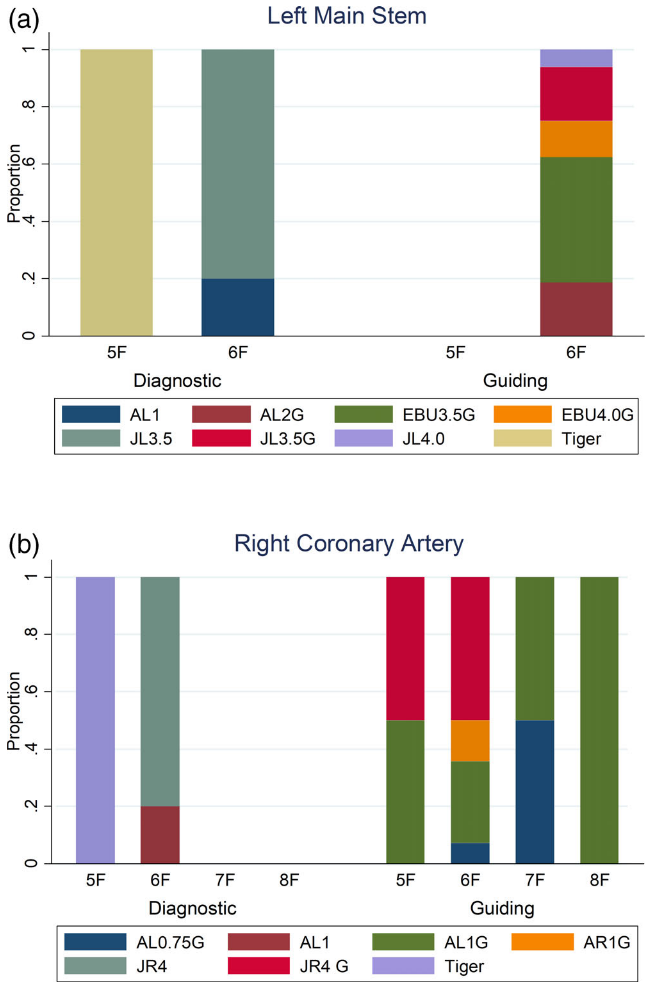

FIGURE 1 (a) The catheters involved in LMS dissection and (b) the catheters involved in RCA dissection. LMS, left main stem; RCA, right coronary artery [Color figure can be viewed at wileyonlinelibrary.com]

3.2 | Classification of iatrogenic dissections and management strategy

Most ICOCAD were high grade (i.e., associated with impairment of luminal flow): 34 cases (67%) were grades D, E, and F (Figure 2(a)). The most common ICOCAD type was F affecting 18 (36%) of cases. The majority of type F dissections (12/18; 66%) occurred in females in their sixth decade of life. The type of dissection affecting each coronary vessel is summarized in Figure 2(b). There was no significant difference in the type of dissection affecting each vessel (p = .30). PCI was undertaken in 42 cases (82%) and CABG in 3 (6%), while 6 (12%) of cases received conservative treatment. The treatment delivered for each dissection type is shown in Figure 2(c). Both cases of LIMA dissections were treated with bailout PCI to the LIMA with drug-eluting stents and safely discharged home (Figure 3). Dissections in the RCA were conservatively managed in 4 (15%), with PCI in 21 (81%) and

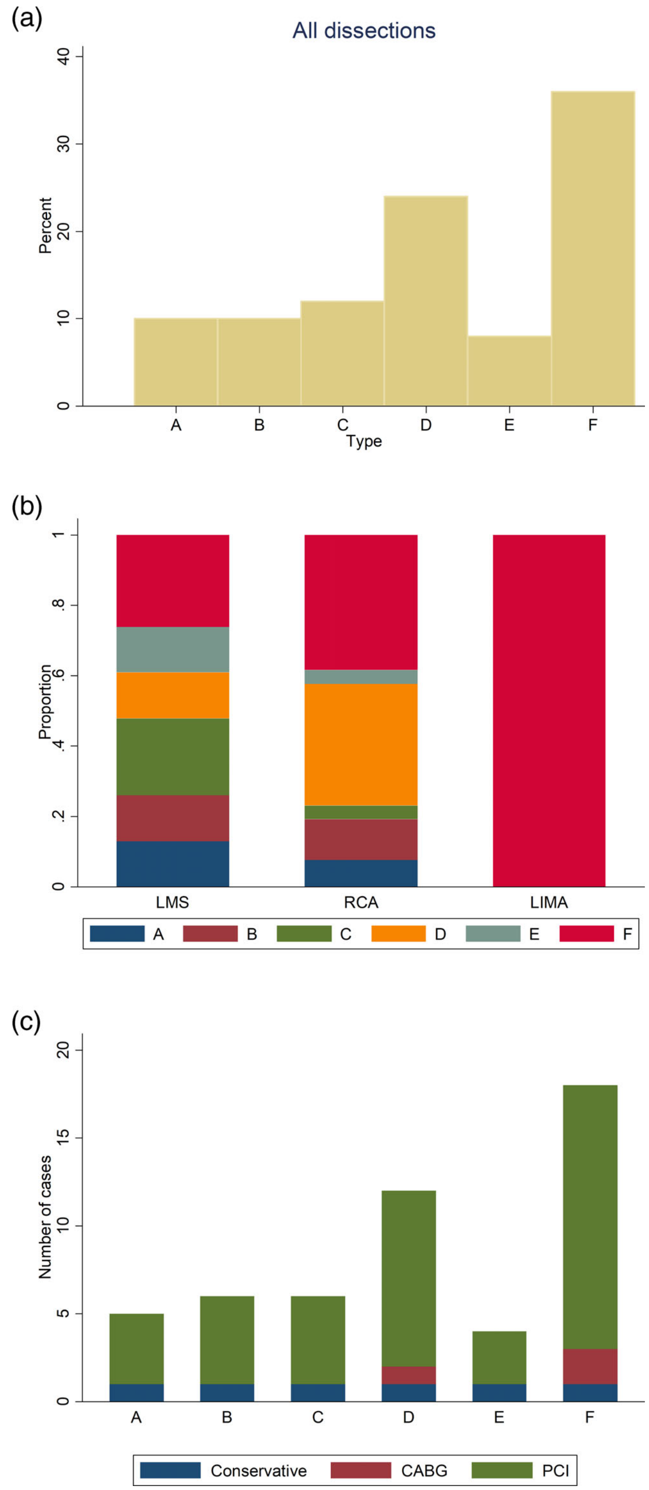

FIGURE 2 (b) Cases of ICOCAD according to the NHLBI classification, (b) type of dissection affecting each vessel and (c) the treatment delivered for each type of dissection. CABG, coronary artery bypass grafting; ICOCAD, iatrogenic catheter-induced ostial coronary artery dissection; LIMA, left internal mammary artery; LMS, left main stem; NHLBI, National Heart, Lung and Blood Institute; PCI, percutaneous coronary artery intervention; RCA, right coronary artery [Color figure can be viewed at wileyonlinelibrary.com]

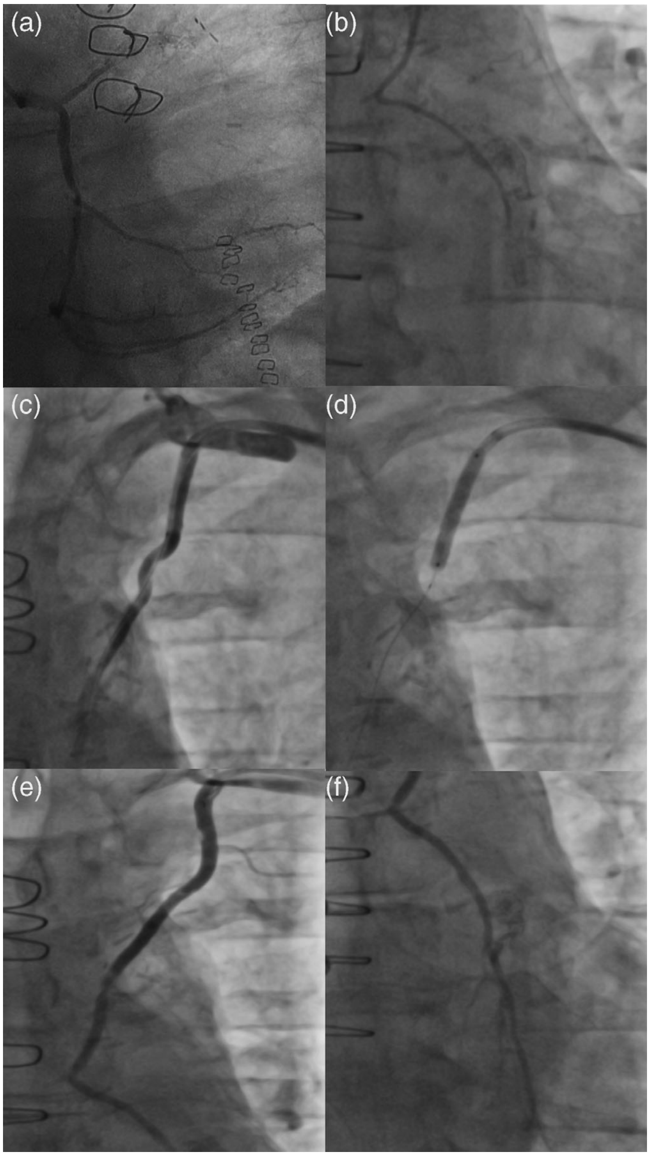

FIGURE 3 Seventy-three-year-old male with previous CABG (LIMA-LAD and SVG-D1) who presented with NSTEMI. (a) Coronary angiography of the native vessels showing severe calcified and long length of occluded LAD stent. (b) Coronary angiography showing occluded distal LIMA/LAD after the insertion point. (c) Following a discussion at the complex coronary multidisciplinary meeting, the plan was to treat LIMA-LAD followed by LMS-LAD. Initial acquisition following IMA guide catheter engagement showed a type F dissection and loss of anterograde flow. (d) The dissection was promptly treated with 2 drug-eluting stents. (e) Final angiographic image showing excellent TIMI III flow in the LIMA. (f) The LAD lesion was treated with one further stent and a drug-eluting balloon, which resulted in good flow in the native LAD. The patient returned for a successful staged PCI-LMS at a later date. CABG, coronary artery bypass grafting; LMS, left main stem; NSTEMI, non-ST-elevation myocardial infarction; PCI, percutaneous coronary artery intervention

CABG in 1 (4%) of cases. Figure 4 shows a representative example of RCA dissection treated with PCI. Dissections in the LMS were conservatively managed in 2 (9%), with PCI in 19 (83%) and CABG in 2 (9%) of cases. One of the patients with LMS dissection was referred for CABG but in effect was conservatively treated as she died prior to the operation (see case 3 below).

3.3 | Mortality associated with iatrogenic coronary artery dissection

Safe discharge was achieved in 48/51 patients (94.1%) but three patients did not survive the admission. There were no deaths post discharge. The cohort was followed up for 220.4 patient years (median 3.6 years; 25th centile: 0.97 years; 75th centile 6.7 years) with a 1-year and 5-year survival of 93.5% (95% CI 81.1 to 97.7%). The three patients who did not survive were all female, presenting with an acute coronary syndrome and had a type F dissection. These three cases are summarized below:

Case 1: A 55-year-old female who presented with NSTEMI. Coronary angiography was performed using the right femoral artery (RFA). RCA angiography with JR4.0 diagnostic catheter caused a type F coronary dissection, which was treated with three stents and abciximab. This was complicated by complete heart block needing temporary wire insertion and ventricular fibrillation requiring defibrillation. Unfortunately, the patient suffered a catastrophic haemorrhagic stroke and died 3 days following angiography.

Case 2: A 73-year-old female who presented with inferior STEMI. Coronary angiography was performed via the RFA. An AR1.0 guide catheter caused an ostial dissection of the RCA, which was promptly treated with a single drug-eluting stent. PCI did not restore flow (TIMI 0) and the patient rapidly deteriorated with cardiogenic shock and died on the same day.

Case 3: A 79-year-old female who presented with NSTEMI. Coronary angiography was undertaken using the right radial artery (RRA). There was a type F dissection of the LMS caused by an AL2.0 guide catheter during an attempt to treat the proximal circumflex culprit lesion (Figure 5). Intra-aortic balloon pump was inserted to aid haemodynamic stability. The patient was accepted for CABG but unfortunately, she died on her way to the operating theater on the same day.

With an intention to treat analysis, five conservatively treated patients survived, 2/42 (4.7%) patients treated with PCI died, and 1/4 (25%) patients referred for CABG died.

4 | DISCUSSION

This study shows that ICOCAD is an uncommon complication of cardiac catheterisation and is primarily caused by guide catheters. The majority of ICOCAD is high grade (types D, E, F) with impairment of luminal flow and can be successfully treated with PCI. Inpatient mortality was 6% and occurred exclusively in patients with type F dissections.

The prevalence of ICOCAD has been reported to be <0.1%[2] but the true burden may be under-estimated. Dissections with minimal contrast persistence (e.g., type A) may go unnoticed during

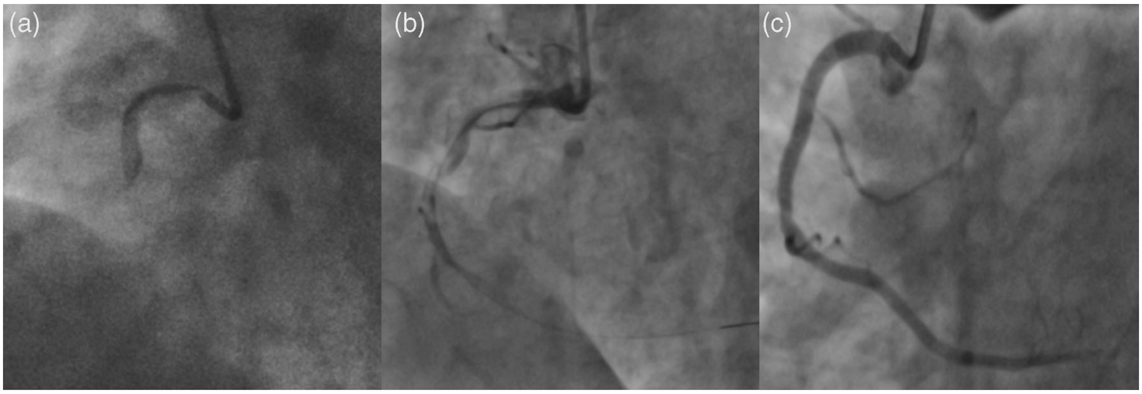

FIGURE 4 Sixty-two-year-old male presenting with an inferior NSTEMI. (a) First acquisition of the RCA with a JR4 guide catheter showed a severe spiral dissection (type F). (b) The RCA was carefully wired with a Sion blue wire. (c) The vessel was treated with two drug-eluting stents and the final angiographic acquisition shows excellent TIMI III flow. NSTEMI, non-ST-elevation myocardial infarction; RCA, right coronary artery

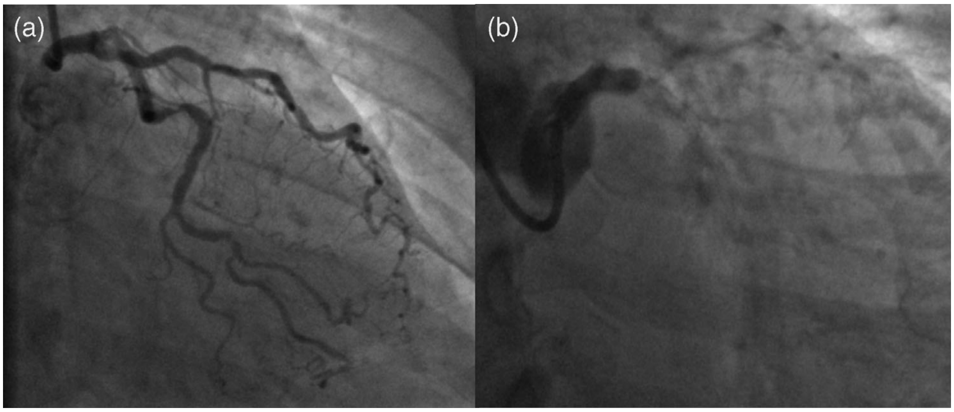

FIGURE 5 Seventy-nine-year-old female who presented with NSTEMI—case 3 in results. (a) Coronary angiography showing a severe stenosis of the proximal circumflex (culprit lesion). Significant tortuosity and calcification of the vessel is noted; (b). An AL2.0 guide catheter was chosen to provide backup support for intervention. First image acquisition following catheter engagement shows a severe LMS dissection with loss of antegrade flow. The patient was accepted for CABG but unfortunately, she died on her way to the operating theater on the same day. CABG, coronary artery bypass grafting; LMS, left main stem

angiography without immediate or long-term clinical squeal. The limited resolution of coronary angiography may also contribute[3,4] but again, this may not be clinically relevant as the majority of small, nonflow limiting dissections probably heal without adverse clinical events.[5] This study confirms that ICOCAD is infrequent in contemporary practice and more likely to occur when using guiding catheters, particularly EBU and Amplatz left for the RCA. Guiding catheters, especially those with extra backup features are often selected to provide adequate support for coronary intervention but may lead to deep intubation and ostial trauma.[6] Ostial disease is another risk factor for ICOCAD and likely to play a role in some cases. Devlin et al reviewed cardiac catherization records over 9 years found that 93% of LMS dissections occurred during the first contact of the catheter with an LMS atherosclerotic plaque.[7] Gordon et al. reported that the rate of LMS dissection was 24% when the end of catheter to plaque distance was less than 6 mm compared to just 3% when the distance was larger than 6 mm.[8] The clinical implication of these findings is that when ostial disease is present or suspected, coaxial positioning of the catheter and avoidance of deep intubation is paramount to prevent plaque disruption and the potential catastrophic consequences of ostial coronary dissection.

Our study shows that large proportion of ICOCAD occurred when catheterisation was undertaken via the radial artery but our institution has a “radial first” approach which has been proven to be associated with early mobilization and overall less complications.[9,10] Coronary catheters have been designed for femoral access procedures and we speculate that in some radial approach cases more aggressive manipulation for catheter engagement or lack of coaxial alignment may predispose to ostial coronary dissections. Data on access route in cases without ICOCAD were not systematically collected and consequently in the absence of a denominator, we have insufficient data to show that radial access is a risk factor for ICOCAD. The role of operator experience could not be assessed.

Our study found that two-thirds of type F dissections occurred in females. This may not be a chance finding and one hypothesis relates to the contributory factor of hormonal changes. Estrogen and progesterone receptors are present in the coronary endothelium. Frequent hormonal changes or imbalance can cause decreased collagen synthesis leading to weakening of arterial wall making them more susceptible to coronary dissections.[11,12] This hypothesis may, to some extent, explain why mortality in type F dissections were exclusively seen in female patients.

ICOCAD can lead to acute vessel closure, myocardial infarction, and death[13] but in some cases there is normal flow to the distal vessel with no myocardial damage and complete healing on subsequent intravascular imaging series.[5] The varied nature and outcome of ICOCAD has contributed to the lack of evidence-based guidelines to assist interventional cardiologists when faced with such predicament. Rogers et al.[14] proposed that small dissections (NHLBI type A and B) are benign and often can be treated conservatively if angiographically stable for 5–10 min. Types C to F coronary dissections carry significant risk of acute closure with a poor outcome and stent deployment is recommended.[14] CABG is a reasonable option for treatment of unstable patients with coronary dissections (especially when unable to wire the true lumen in a modest caliber vessel) but it is a high-risk operation with the need for cardiothoracic team to be available round the clock for emergency procedures.[15] This has led to PCI being the mainstay treatment for larger dissections with or without haemodynamic instability.[16] This study demonstrates that timely treatment with bailout stenting leads to a relatively favorable short-term outcome if flow can be preserved. Our data also show that most interventional cardiologists in our institution tend to treat even low-grade ICOCAD with PCI. It is not clear from the literature how widespread this practice is but our data show that this is a safe approach in the short term.

5 | CONCLUSION

ICOCADs are uncommon but important complication of cardiac catheterisation. Most cases are caused by guide catheters which may cause deeper, traumatic intubation. The need for guiding catheter support should be balanced against the risk of ICOCAD especially in the presence of ostial coronary artery disease. Low-grade coronary artery dissections in patients who are haemodynamically stable may be managed conservatively. In the majority of patients, timely recognition and prompt bailout PCI is a feasible option for high-grade dissections and should be considered early to facilitate good clinical outcomes. Female patients may be more predisposed to high-grade dissections and have worse outcomes.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

DATA AVAILABILITY STATEMENT

Data available on request from the authors

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