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CASE REPORT
Coronary intervention

Late stent thrombosis as a complication of T and small protrusion bifurcation stenting: a case report

Gregory Offiah *, Paul McGrath, and Peter Kearney

Department of Cardiology, Cork University Hospital, Wilton, Cork T12 DC4A, Ireland

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Background A case of stent thrombosis as a complication of coronary bifurcation stenting is described. We review potential complications of bifurcation stenting and established guidelines.

Case summary A 64-year-old man presented with a non-ST segment elevation myocardial infarction. High-sensitivity troponin I peaked at 99 000 ng/L (normal <5). He previously had coronary stenting for stable angina when residing in another country 2 years previously. Coronary angiography revealed no significant stenosis with TIMI 3 flow in all vessels. Cardiac magnetic resonance imaging demonstrated a left anterior descending artery (LAD) territory regional motion abnormality, late gadolinium enhancement consistent with recent infarction, and a left ventricular apical thrombus. Repeat angiography and intravascular ultrasound (IVUS) confirmed bifurcation stenting at the junction of the LAD and second diagonal (D2) with protrusion of several millimetres of the uncrushed proximal segment of the D2 stent in the LAD vessel lumen. There was under-expansion of the LAD stent in the mid-vessel and stent malapposition in the proximal LAD, extending into the distal left main stem coronary artery and involving the ostium of the left circumflex coronary artery. Percutaneous balloon angioplasty was performed along the length of the stent, including an internal crush of the D2 stent. Coronary angiography confirmed a uniform expansion of the stented segments and TIMI 3 flow. Final IVUS confirmed full stent expansion and apposition.

Discussion This case highlights the importance of provisional stenting as a default strategy and familiarity with procedural steps in bifurcation stenting. Furthermore, it emphasizes the benefit of intravascular imaging for lesion characterization and stent optimization.

Keywords Coronary bifurcation lesions • Percutaneous coronary intervention • Intravascular ultrasound • Acute coronary syndrome • 1 vs. 2 stent strategy • Case report

ESC Curriculum 3.1 Coronary artery disease • 3.2 Acute coronary syndrome • 3.4 Coronary angiography • 3.3 Chronic coronary syndrome

Learning points

- In bifurcation stenting, provisional stenting and limiting the number of stents should be considered the default treatment strategy in simple non-left main true bifurcation lesions.
- Close adherence to procedural steps is imperative to avoid complications in bifurcation stenting.
- In bifurcation stenting, intravascular imaging should be considered for procedural planning and stent optimization.

* Corresponding author. Tel: +353877637995, Email: goffiah@tcd.ie
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Introduction

Coronary bifurcation lesions are defined as significant stenoses in a coronary artery involving or adjacent to the origin of a side branch.[1] Data from prior meta-analysis has supported a single stent strategy for the management of bifurcation lesions, due to an association with reduced all-cause mortality.[2] Consequently, provisional stenting has been recommended as a default strategy for the vast majority of patients.[3] This case calls attention to potential adverse outcomes associated with a two-stent technique and the need for familiarity with procedural steps to avoid complications.

Timeline

Two years prior	Presents with stable angina Left anterior descending artery (LAD) stenting is performed with stenting of the second diagonal (D2) as a bailout strategy
Day of presentation January 2022	Experiences chest pain Elevated high sensitivity troponin and Wellen's type A changes on electrocardiogram (ECG)
Day 2 of admission January 2022	Coronary angiography revealed non-obstructed coronary arteries with TIMI 3 flow in all arteries Takotsubo cardiomyopathy included in the differential diagnosis Transthoracic echocardiography shows antero-apical hypokinesis
During hospital admission January 2022	Cardiac magnetic resonance imaging (MRI) shows distal LAD territory late gadolinium enhancement and regional wall motion abnormalities consistent with acute infarction Repeat angiography and intravascular ultrasound (IVUS) revealed under-expanded LAD stent, proximal stent malapposition, and protrusion of the D2 stent into the LAD lumen Balloon angioplasty was performed along the length of the LAD
Prior to hospital discharge January 2022	Treated with warfarin and clopidogrel to allow resolution of left ventricular thrombus identified on cardiac MRI
Hospital follow-up June 2022	Warfarin discontinued Treated with lifelong dual antiplatelet therapy (aspirin and clopidogrel)

Case report

A 64-year-old male patient presented with a 5 h history of severe sudden onset central chest pain. His admission ECG showed normal sinus rhythm with no acute ischaemic changes. Over a 12 h period, he developed Wellen's type A (*Figure 1*) and subsequently Wellen's type B ECG changes. High-sensitivity troponin I was 4177 ng/L (normal <5) initially and peaked at 99 394 ng/L on a repeat sample taken 6 h later. Of note, the patient had a history of coronary stenting for stable angina 2 years prior to this presentation in another country, and details of the intervention were not initially available.

A standard regimen for non-ST segment elevation myocardial infarction was initiated, including dual antiplatelet therapy with aspirin and ticagrelor. Diagnostic coronary angiography revealed TIMI 3 flow in all vessels and patent LAD stent with mild diffuse attenuation within the D2 stent and an ambiguous appearance in the mid-segment of D2 consistent with intraluminal thrombus (see Supplementary material online, *Video S1*). Intravascular imaging was not performed during this procedure. Takotsubo cardiomyopathy was considered in the initial differential diagnosis. Antero-apical hypokinesis was identified on transthoracic echocardiogram. Cardiac magnetic resonance imaging confirmed a distal LAD territory regional wall motion abnormality and late gadolinium enhancement, as well as oedema and post-gadolinium sequences suggestive of no reflow at the apex (*Figure 2*). These findings were consistent with acute infarction. There was also a small left ventricular (LV) apical thrombus, which was not initially identified on echocardiography. Angiographic images and reports from the patient's previous coronary intervention were eventually received. This revealed T and small protrusion (TAP) bifurcation stenting of the LAD and second diagonal (D2), with 3.5 × 48 mm Xience and 2.5 × 15 mm Xience Sierra stents, respectively. This strategy was pursued as a 'bailout' option following side branch occlusion as a result of deliberate LAD stenting. A diagnosis was made of acute myocardial infarction, arising from embolization of very late LAD stent thrombosis, with complete resorption of embolized thrombus in the distal LAD and residual small thrombus burden in D2.

Repeat angiography was performed with IVUS (see Supplementary material online, *Video S2*), which revealed an under-expanded LAD stent throughout its course with malapposition at the proximal end of the stent, which extended into the left main stem coronary artery and extended across the ostium of the left circumflex coronary artery (*Figure 3*). IVUS also identified a circular strutted structure adjacent to the ostium of D2 and extending proximally, consistent with the D2 stent protruding several millimetres into the lumen of the LAD (*Figure 4*). The left main stem and mid-LAD measured approximately 6.0 and 4.5 mm in diameter on IVUS, respectively.

A Sion blue wire was passed down the LAD, ensuring the tip was directed to the opposite side of the vessel to the ostium of D2 to prevent crossing through the side branch stent struts. Balloon angioplasty was performed along the length of the LAD stent using a 4.0 × 15 mm Emerge non-compliant balloon to high pressures to perform an internal crush of the protruding D2 stent and to ensure adequate stent expansion along the vessel length. A 5.0 × 8 mm non-compliant Emerge balloon was inflated to high pressures at the proximal end of the LAD stent. Subsequent IVUS images (see Supplementary material online, *Video S3*) confirmed a fully expanded stent with a satisfactory final angiographic result. A decision was made not to rewire the LADD2 and perform a final kissing balloon inflation in view of the optimal appearances of the LAD and calibre of the LADD2 subtending of the infarcted territory. Following a 6-month period of anticoagulation with warfarin (INR targets 2–3) and single antiplatelet treatment with clopidogrel to allow resolution of the LV thrombus, the patient was discharged on lifelong dual antiplatelet therapy (aspirin and clopidogrel).

Discussion

This case highlights the importance of procedural planning and intravascular imaging guidance for stent optimization in bifurcation stenting. Our patient's previous intervention included side branch stenting using the TAP technique due to side branch (SB) compromise following main

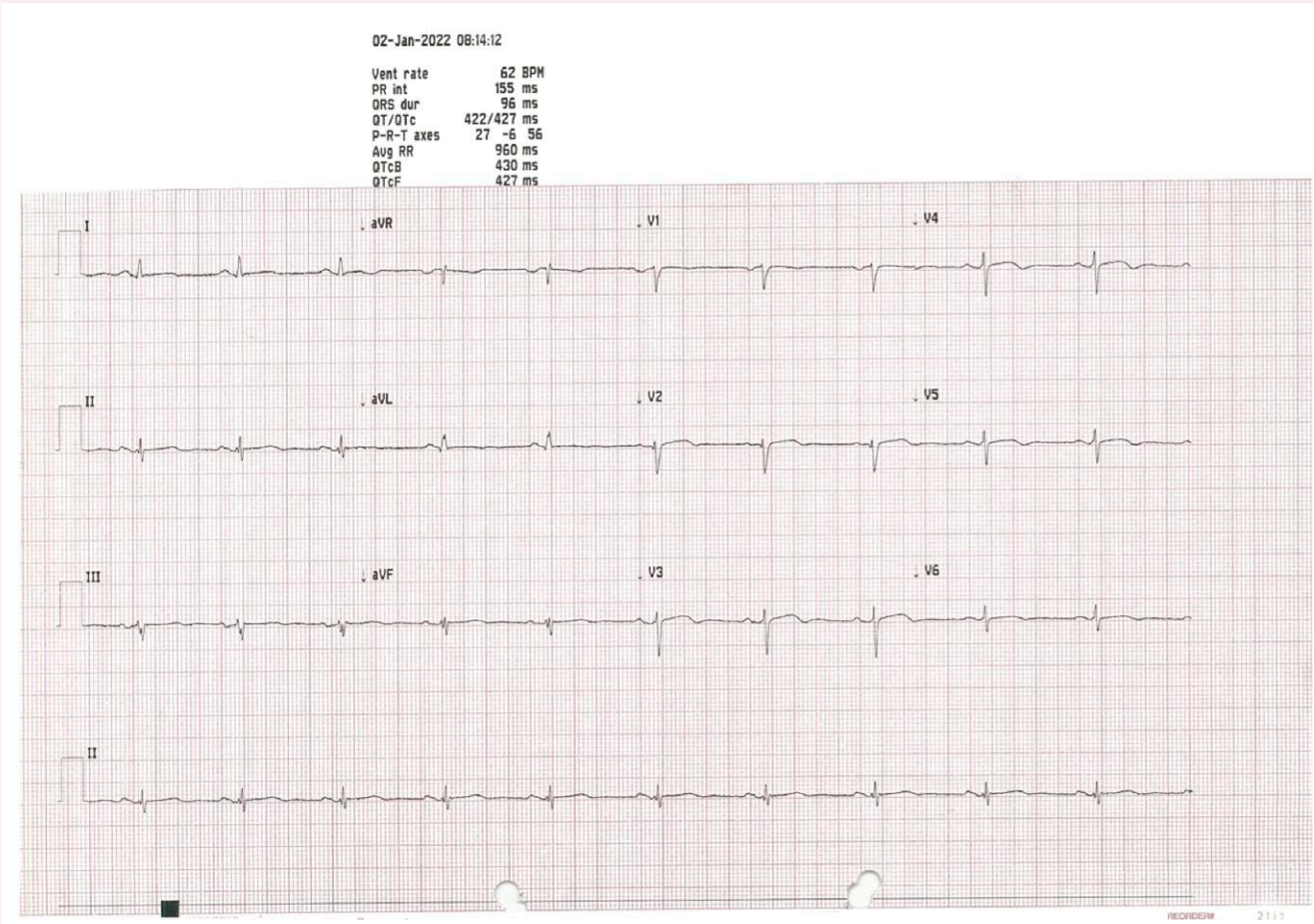

Figure 1 Electrocardiogram showing sinus rhythm with Wellen's type A changes.

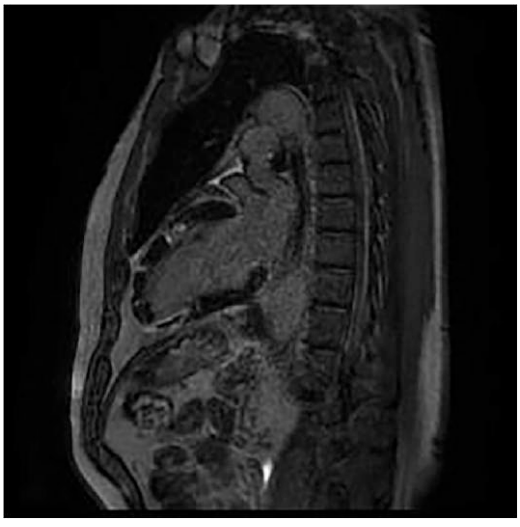

Figure 2 Magnetic resonance imaging in long axis view showing no reflow.

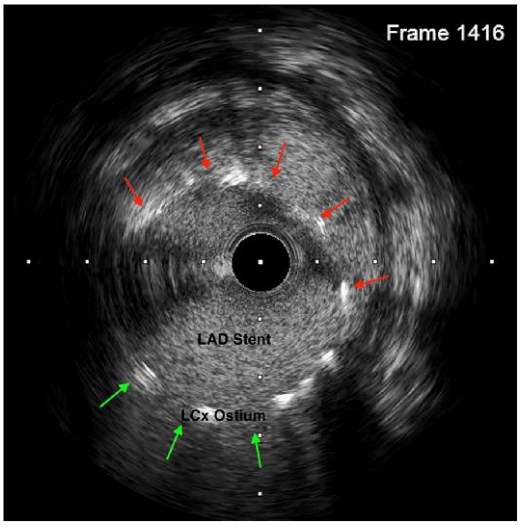

Figure 3 Intravascular ultrasound of malapposed proximal left anterior descending artery (LAD) stent at the distal end of the left main stem coronary artery (downward arrows) with involvement of the ostium of the left circumflex (LCx) coronary artery (upward arrows).

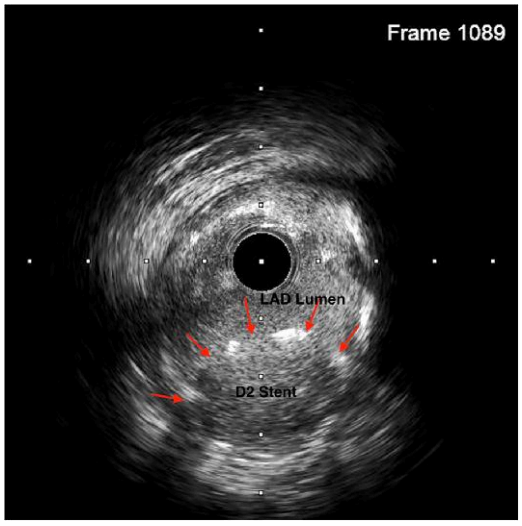

Figure 4 Intravascular ultrasound of the under-expanded mid-left anterior descending artery (LAD) stent at the level of the second diagonal (D2) stent, which extends into the lumen of the main vessel (downward arrows).

vessel (MV) stenting. Current European guidelines and the recently published European Bifurcation Club's 16th consensus document recommend provisional stenting as a default strategy in non-left main true bifurcation lesions.[3,4] Furthermore, the number of stents used in a procedure should be minimized[3], and there should be close adherence to procedural steps in bifurcation stenting to avoid complication. In the case of TAP stenting, there should be the least possible protrusion of the SB stent into the MV lumen to ensure SB ostium coverage without excessive protrusion of the SB stent into the MV lumen, according to the principle that 'the best TAP is T'.[5] In this case, previous SB stenting had resulted in a long segment of unapposed small stent within the larger MV stent, cultivating an environment for increased thrombotic risk.

The DEFINITION II trial showed favourable outcomes for a two-stent strategy compared to provisional stenting in complex bifurcation lesions.[6] Nonetheless, the majority of the two-stent strategy cohort was treated with a DK crush technique, which is emerging as a favoured technique for upfront bifurcation lesion stenting. Furthermore, simple bifurcation lesions may reasonably be treated with a provisional approach. Recently, published data from *post hoc* analysis of the SYNTAX trial showed a two-stent strategy in coronary bifurcation lesions was associated with an increased risk of repeat revascularization at 5 years and increased risk in 10-year mortality, compared to those treated with one stent.[7] A second stent is required in only 5–25% of cases treated with a provisional strategy.[6] Frequently, a jailed SB can be adequately treated with kissing balloon inflation alone.[3,8] Simple measures such as SB wire jailing have been shown to lower rates of final side branch occlusion, while a jailed SB balloon technique may avoid the need for SB stenting in high-risk cases.[9]

IVUS is a useful tool to guide intervention and stent optimization in bifurcation stenting. Its use is recommended to mitigate the risk of carina shift and SB occlusion in bifurcation stenting by assessment of true lumen dimensions, plaque burden and distribution, and stent landing zones prior to stenting.[10] IVUS-guided stent optimization in non-left main stem coronary bifurcation lesions was found to be associated with less very late stent thrombosis in patients compared to angiography alone.[11] Consequently, IVUS or optical coherence tomography, depending on user experience and availability, should be considered to guide the stenting of bifurcation lesions. In this case, IVUS revealed extensive malapposition as a consequence of under-expansion of the LAD stent in the large proximal LAD lumen that clearly had gone unrecognized at the time of implantation.

The optimal duration of DAPT following intervention for very late stent thrombosis is unknown, and studies of prolonged (>12 months) DAPT in a general population of stented cases (by definition at lower thrombotic risk) have shown reduced stent thrombosis and MI, at a cost of increased bleeding and a signal of increased mortality.[12,13] Decisions regarding prolonged DAPT in very high thrombotic risk cases, such as ours, need to be considered on an individual basis. Arguably, having remedied identifiable risk factors for stent thrombosis (malapposition and extrusion of the side branch stent into the main vessel lumen), lifelong DAPT may not be necessary.

Conclusion

This case highlights the importance of close adherence to procedural steps to avoid complications in bifurcation stenting. Provisional stenting and limiting the number of stents should be considered the default treatment strategy in simple non-left main true bifurcation lesions and intravascular imaging should be considered for procedural planning and stent optimization.

Lead author biography

Gregory Offiah is a specialist registrar in cardiology training in Ireland. He has a special interest in coronary intervention.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports* online.

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There are no conflicts of interest.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as supplementary data.

Consent: The authors confirm that written consent for the publication of this case reports has been obtained from the patient in accordance with the COPE guidelines.

Conflict of interest: None declared.

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Data availability

All available data has been presented in the manuscript.

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