

CASE REPORT

A cascade of multiple complications hampering a complex high-risk percutaneous coronary intervention (CHIP-PCI): When ingenuity overcomes troubles!

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Abstract

Even skilled CHIP operators can run into multiple complications. Some are unexpected and not related to the operator, and others are fully preventable by careful procedural choices. If those occur, the knowledge of devices and cognitive skills become lifesaving elements and sudden issues need to be dealt with calmly and efficiently.

KEYWORDS

CHIP-PCI, chronic coronary syndrome, coronary artery perforation, CTO, longitudinal stent deformation

1 | INTRODUCTION

Complex, higher-risk, and clinically recommended percutaneous coronary interventions could still be challenging in interventional cardiology. Advanced catheter-based procedures should be used to address this high-risk subset of patients. However, despite the development of new devices and techniques, life-threatening complications may occur and the knowledge of how to overcome them effectively becomes crucial.

A growing number of patients with coronary artery disease (CAD) need complex and clinically indicated percutaneous coronary interventions (CHIP-PCI).

Advanced age, multiple comorbidities, and some anatomical circumstances such as left main and/or bifurcation disease, long and calcified lesions, and chronic total occlusions are factors that may lead to a patient being considered a candidate for CHIP-PCI.

Improved medical devices and operator expertise increased the safety of the procedure. Nevertheless, complications such as coronary perforations, stent loss and/or dislodgment and acute vessel occlusions can still occur and may become life-threatening.¹

If one of the aforementioned complications happens, technical and cognitive skills are of paramount importance resulting in a timely and an effective lifesaving treatment.

2 | CASE REPORT

A 75-year-old female, hypertensive, diabetic patient, on dialysis, presented to our institution with a past medical history of dyspnea and effort angina which recently worsened into a rest angina. Perfusion defects were present in the anterior- and inferior-lateral walls at thallium scan, and the left ventricular function was preserved (Figure 1).

Coronary angiography showed diffusely calcified vessels with a proximal left anterior descending (LAD) artery, chronic total occlusion (CTO), and a subocclusive stenosis in the large first diagonal branch (D1). The left circumflex coronary artery (LCx) was severely narrowed at the ostium (Figure 2A).

A contralateral injection filled the thin, calcified LAD (Figure 2B).

The Heart Team deemed surgery was not recommendable because of comorbidities, extensive calcifications, and poor

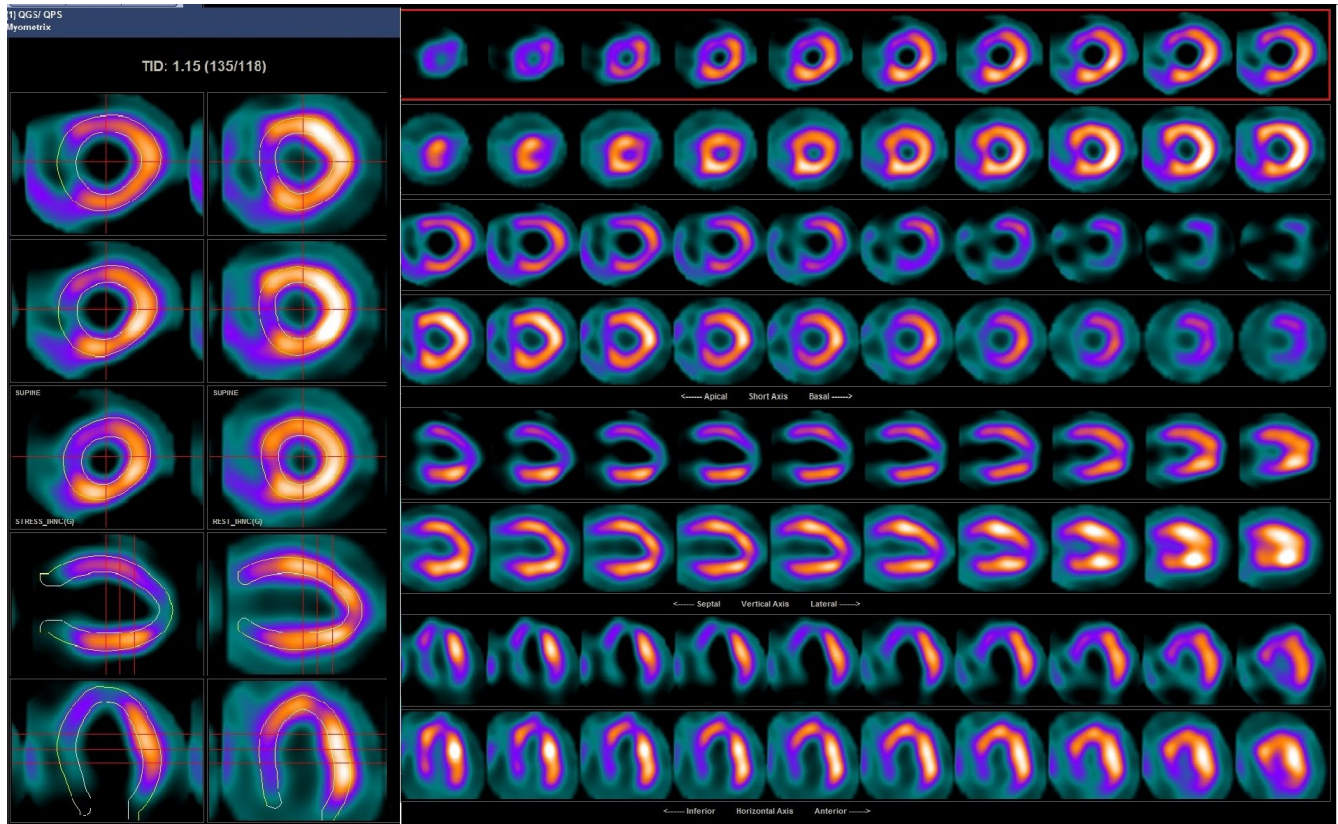


FIGURE 1 Thallium scan

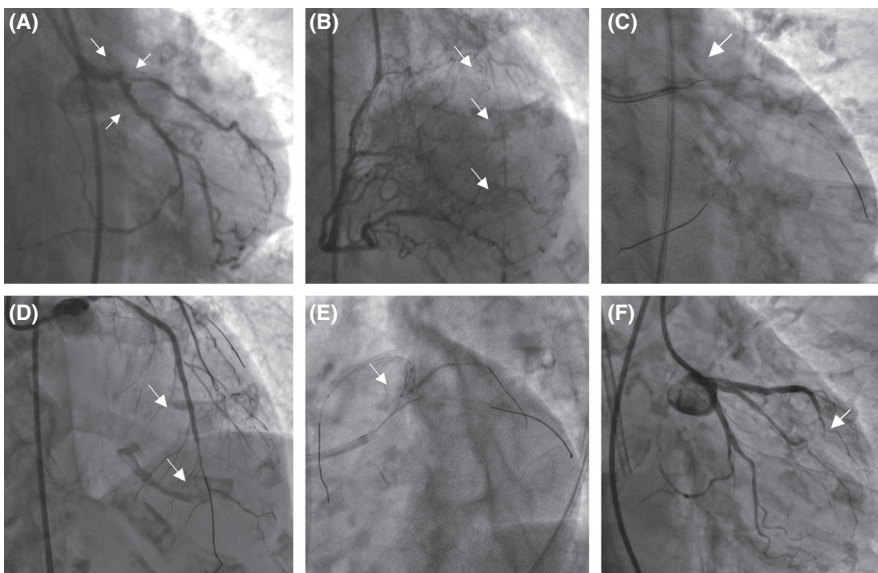


FIGURE 2 A, LAD-CTO; LCx and D1 severe narrowing. B, Collateral circulation for LAD. C, CTO crossing (arrows). D, Final result on mid-distal LAD (arrow). E, Culotte and TAP techniques (arrow). F, Late distal LAD occlusion (arrow)

run-off of LAD. A combined LAD-CTO and left main (LM) bifurcation procedure was planned.

After administration of unfractionated heparin (ACT: 240 seconds), the LAD-CTO was crossed with a polymer-jacketed hydrophilic Pilot 150 guidewire (Abbott Vascular) supported by a microcatheter. Given the microcatheter did not go beyond the CTO, multiple predilatations

with conventional balloons were performed, and then, the hydrophilic guidewire was replaced with a workhorse one. Two cobalt-platinum zotarolimus-eluting overlapped stents (2.5/22 mm; 2.75/26 mm: Resolute Onyx™-Medtronic) were implanted in the mid-LAD segments, while a long 2.0/30 mm drug-eluting balloon (DEB) was used to treat the distal LAD (Figure 2C).

The culotte technique and the T and protrusion were used to treat respectively the LM- and the LAD-D1 bifurcations (4.0/22 mm, 3.5/26 mm and 3.0/18 mm: Resolute Onyx™-Medtronic) optimized with multiple kissing and proximal high-pressure inflations (Figure 2D,E).

Despite an initial good result, the distal LAD re-occluded at the site of the DEB treatment (Figure 2F).

A 2.25/22 mm Resolute Onyx™ stent was set to be delivered in the distal LAD. However, it got trapped in the proximal LM stent.

Moreover, X-ray enhancing confirmed that the stent was embedded in the struts of the previously implanted LM stent, dislodged, and with an evident longitudinal stent deformation (LSD) (Figure 3A) (Video S1).

Since the guidewire access was lost and the wire braiding technique failed, we successfully retrieved the stent with a gooseneck device (Figure 3B,C) (Video S2).

Utilizing a mother-in-child technique, a guide extension catheter (Telescope™-Medtronic Inc) was advanced through the LM bifurcation and a new 2.0/22 mm Resolute Onyx stent was implanted at its nominal pressure in the distal LAD (Figure 3D).

After postdilatation, a type III extravasation at the 2.25/22 mm distal stent and a type V extravasation related to the use of the stiff hydrophilic guidewire used during the CTO crossing became evident (Figure 3E,F) (Video S3). Unfractionated heparin was partially neutralized with a half-dose of protamine (recommended dose of 1 mg intravenously for each 100 units of unfractionated heparin), and multiple prolonged balloon inflations sealed the perforations (Figure 4A).

The patient was closely monitored showing a stable clinical status and a minimal pericardial effusion at echocardiogram.

Nevertheless, 1 hour later, a cardiac tamponade was abruptly developed, and a pericardial drainage was urgently

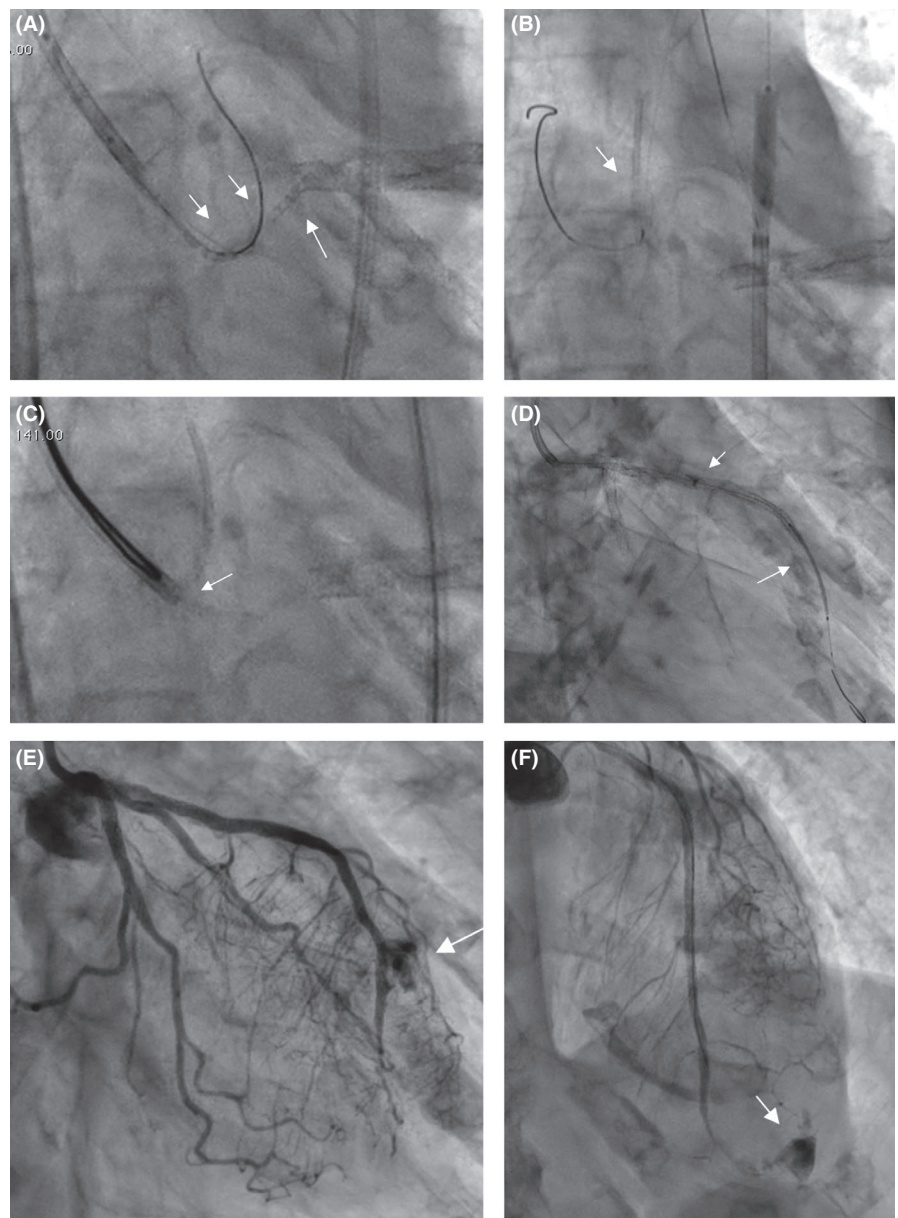


FIGURE 3 A, Longitudinal stent deformation (arrows). B, Failure of the double-guidewire and balloon technique. C, Gooseneck-stent retrieving (arrow). D, GEC and stent delivery (arrows). E, Type III extravasation (arrow). F, Type IV extravasation (arrow)

performed by the cardio-thoracic surgeon without the advisable re-institution of the anticoagulation.

However, the hemodynamic conditions worsened and an anterior ST elevation with diffuse and severe left ventricular hypokinesia was suddenly developed requiring vasopressor and the insertion of an intra-aortic balloon pump (Figure 4B). Immediate angiography showed a thrombotic occlusion of the LM (Figure 4C).

Heparin was re-administered. Multiple manual thrombus aspirations, and kissing balloon inflation restored a TIMI flow grade III (Figure 4D,E).

Regrettably, the multiple previous leakages appeared once again.

The GEC was immediately pushed beyond the extravasation, providing a prompt mechanical hemostasis, and facilitating the delivery of a covered stent, which sealed the proximal vessel rupture (Figure 4F).

Since neither coils nor thrombin were available, the distal extravasation was treated as follows:

Fat was harvested from the subcutaneous tissue at the femoral access site using forceps. It was cut into a very small globule (approximately 0.5-1 mm in thickness) using a scalpel and loaded onto the guidewire and between two tips of cut off used balloons (only the proximal fragment of each balloon was used) resembling “parachutes,” which stabilized the fragment of fat pierced onto the guidewire (Figure 5A,B,C,D). Then, the assembly was pushed with a standard balloon into the proximal hub through the GEC catheter, thus sealing the perforation (Figure 5E,F). Permanent hemostasis was achieved and the hemodynamic status recovered (Figure 5F,G,H)(Video S4).

During the hospital stay, the patient remained pain-free, without dyspnea, showing good ventricular function and only

a mild apical hypokinesia at subsequent echocardiograms. Neither pathological Q-waves nor further development of pericardial effusion were detected. Exceptionally, a predischARGE angiography was performed to be certain of the absence of any minimal distal leakages considering the new adopted sealing technique. The main vessels resulted patent, with no evidence of thrombosis, and no further leakages at the occluded distal LAD segment (Figure 6A,B,C).

3 | DISCUSSION

In recent years, the percentage of CHIP interventions have significantly increased mainly due to patients who have been turned down by the Heart Team for surgical revascularization because of their significant comorbidities.

However, when CHIP-PCIs are the clinically recommended procedures, despite increasing success rates and improving procedural safety margins, life-threatening complications keep occurring. Some of these are unexpected and unrelated to the operator, and others may be the direct or indirect consequences of intraprocedural mistakes.

Among said complications, stent loss deformation, coronary artery perforation (CAP), and abrupt closure are the most life-threatening and challenging to overcome. In our case, the aforementioned complications merged all together.

It has been recently highlighted that stent loss may occur if the distal tip engages a calcified and/or angulated lesion or the struts of a previously implanted stent remaining embedded when the balloon is retracted for repositioning. Both conditions predispose to the LSD of the stent defined as

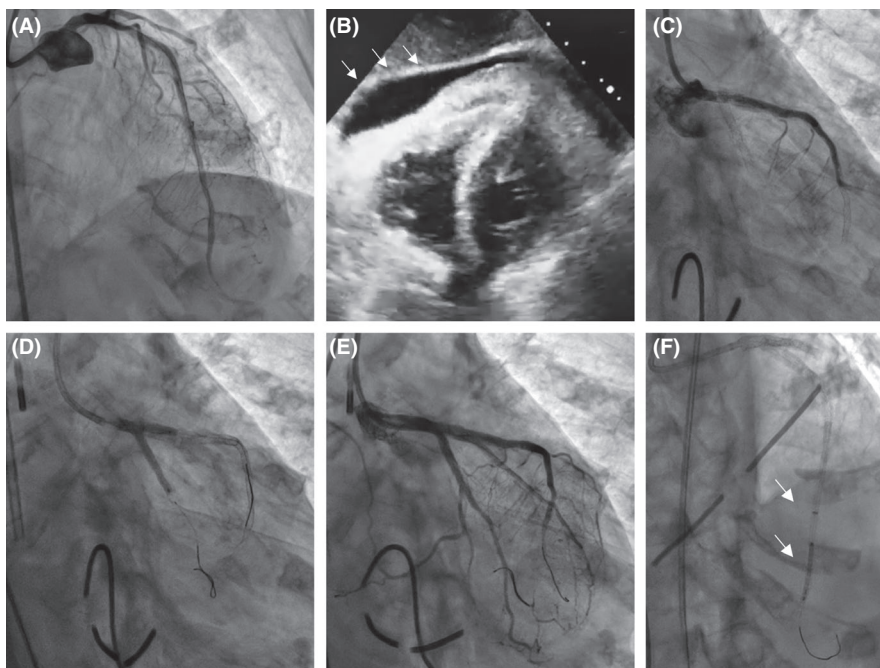


FIGURE 4 A, Sealing after prolonged balloon inflation. B, Tamponade (arrows). C, Thrombotic abrupt LM-LCx and prox LAD occlusion. D, Rescue PCI. E, Anterograde flow restored. F, GEC and covered stent (arrows)

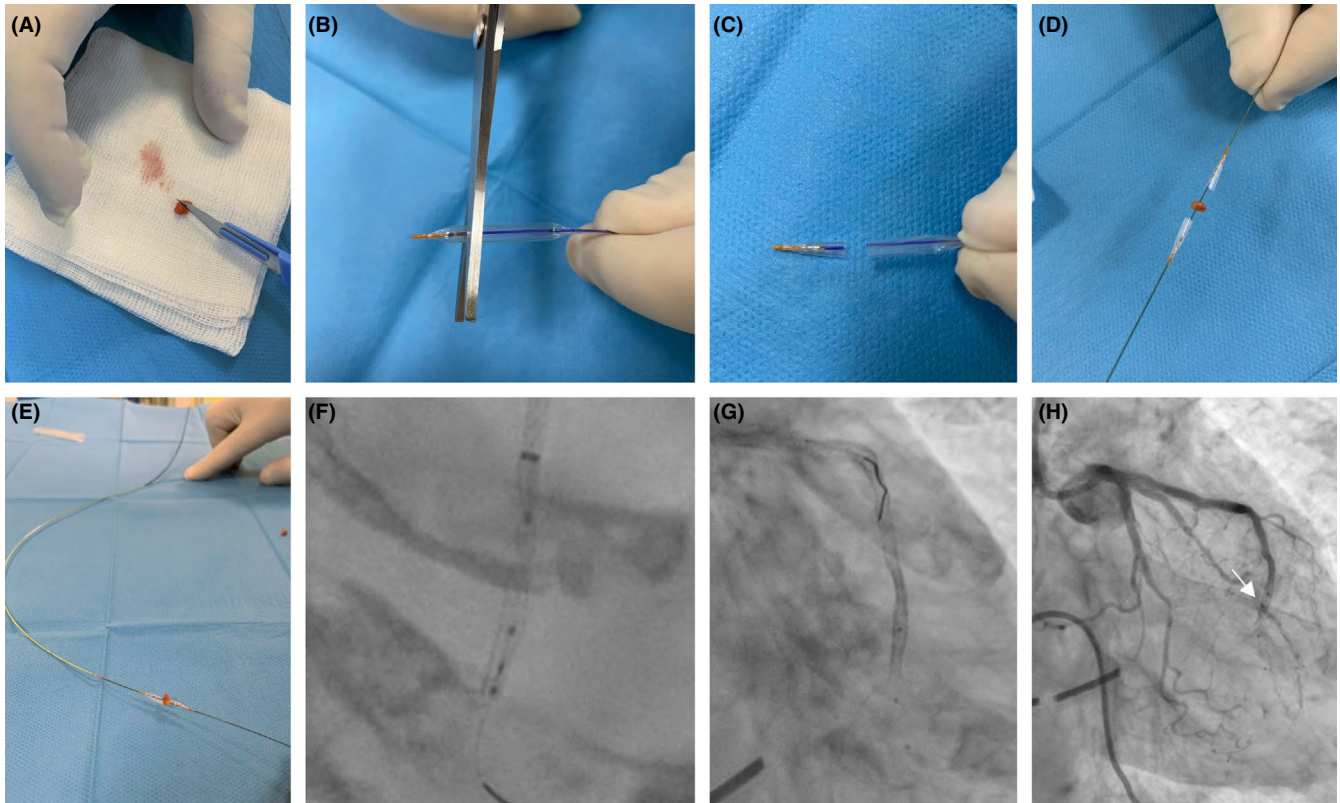
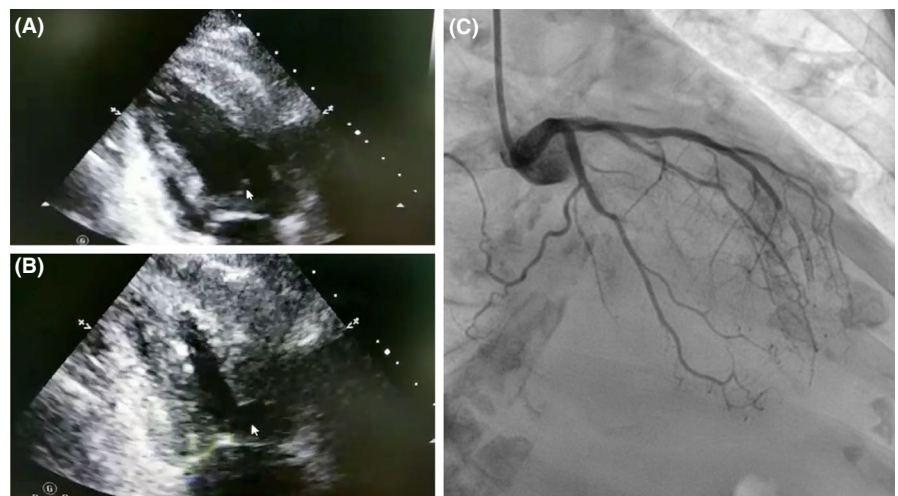


FIGURE 5 A, Fat harvested and cut into a small globule. B, C, Cutting off tips of used balloons. D, Fat globule loaded onto the guidewire and between two tips of cut off used balloons. E, Standard balloon loaded onto the guidewire to push the assembly. A, GEC and tips cut off (particular). B, Covered stent and tips cut off. C, Successful sealing of the distal LAD extravasation (arrow)

FIGURE 6 A, B, Echocardiographic follow-up. C, Angiographic follow-up



distortion, elongation, or shortening of a stent along its longitudinal axis,¹ and some specific stents have higher tendency to LSD.

Initially, the vast majority of stents were manufactured with stainless steel and varied somewhat in their cell geometry and strut thickness. New-generation cobalt-chromium or platinum-chromium stents, albeit with similar radial strength and radiopacity compared with stainless steel

stents, are characterized by better trackability, pushability, and deliverability allowing successful navigation in complex lesions.

However, although innovative designs have enabled preservation of radial strength, the longitudinal strength may be lower and some stents seem to be more prone to that issue with differing in stent deformation incidence observed across the different stent platforms.

In fact, some reports showed a rate of stent deformation in nearly 1% of Promus Element stents deployed (0.86%) compared to 0.1%–0.2% with other platforms (no cases associated with the Xience V/Promus or Cypher stents were identified) and frequent pseudo-fractures of the Endeavor/Micro Driver stent with wide separation of struts related to a very open cell stent design were observed.²

Meaningfully, modern drug-eluting stents have a reduced number of fixed links between cells and the alteration of their geometry partly sacrifices their longitudinal strength, leading to an increased risk of LSD.³ When LSD occurs, and the stent remains on the wire, wire braiding technique (removal of stent with two twisted wire) and inflation of small balloon distal to the stent with subsequent removal of whole system may be employed. If attempts for retrieval are unsuccessful, the guidewire access is lost, and the stent is damaged, the embolized and/or deformed stent could be retrieved using various gooseneck snares, which may result particularly effective as in this case.⁴

With regard to CAP, although a rare event, it may be one of the most disastrous complications.

Depending on the bleeding control, complete management modalities should be considered from surgery to less-invasive percutaneous techniques such as covered stents/grafts or thrombus-inducing therapies (polyvinyl alcohol, autologous blood, or intracoronary bead injection). Moreover, in the event the perforation is in a small branch, a definitive sealing of the perforation site can also be achieved with the local delivery of subcutaneous fat, the use of thrombin, occlusive coils, or beads selectively injected into the distal target with the aid of a microcatheter.⁵

Different mechanisms caused perforations in our case. While the extravasation occurring at the stent site could be referred to the presence of diffuse calcification, since both the stent-vessel matching and the nominal pressure were respected, conversely the delayed appearance of the distal perforation should be related to the hydrophilic guidewire used to cross the LAD-CTO and not immediately replaced with a softer one. This represented the first avoidable procedural error of the operator.

Literature suggests that guidewire-induced perforation seems to be the most frequent cause of CAP accounting for 20%–68% of CAP incidents, and in complex PCI, including chronic total occlusions and bifurcation lesions, the use of both hydrophilic and heavy-weight guidewires has also increased the frequency of this complication.⁶

In fact, a retrospective analysis of the angiogram led to the suspicion that a loop-shaped tip configuration of distally placed hydrophilic guidewires in coronary arteries caused this complication while pushing the balloon used for the CTO dilatation.

Well-recognized mechanisms of perforation with wires include vessel piercing, distal migration, and wire fracture. Another reported mechanism is the hydrophilic guidewire

looping with this unusual tip configuration of the wires at the level of the contrast extravasation. A loop in the distal portion of a wire is often thought of as being safe because it reduces the risk of wire migration and lodgment in small collateral branches. However, when using hydrophilic wires, this “loop configuration” represents an extremely dangerous situation that must be carefully avoided. In this configuration, the wire can act as a blade, cutting easily through the vessel intima and protruding into the pericardial cavity.⁷

With regard to the usefulness of the GECs, they are most frequently used to deliver the devices distally over the calcified lesions, in tortuous or angulated vessels⁸ and/or when it may be difficult to negotiate through previously deployed stents. Further, the GEC could accommodate various bulky devices without any resistance, such as PTFE-covered stents and multiple wires and balloons. Here, the GEC easily crossed the angulated and stented LM bifurcation, thus resulting particularly useful for obtaining the provisional sealing right after it was deeply advanced across the hole. Moreover, it resulted highly supportive for the delivery of both the bulky covered stent and the globule/cut off balloon assembly used to seal the distal perforation.

The management of the type V perforations firstly considers a proximal balloon inflation, which is most of the times sufficient to seal the leak. However, if contrast extravasation persists, vessel embolization may be considered with gel-foam, clotted autologous blood, polyvinyl alcohol, and ideally thrombin.⁹

However, some drawbacks affect their use: When injecting the aforementioned thrombus-inducing therapies, care must be taken to prevent spilling of these in other coronary arteries or branches by inflating a balloon proximal to the injection site, or injecting through the distal lumen of an inflated over-the-wire balloon. Conversely, although PTFE-covered stent implantation at the site of rupture has become a widespread technique to treat proximal coronary artery perforations, in cases of distal guidewire perforation, it is often impossible to deliver such a device.

Other strategies to seal the perforation such as the microcoil embolization and use of subcutaneous tissue have been employed with various success with the former offering the advantage of precise placement into very distal locations.

Moreover, microcoil embolization provides several additional advantages:

Firstly, they can be prepared easily and deployed rapidly. Secondly, by using a microcatheter as a delivery device, microcoils can be inserted accurately without any damage to the parent vessel. Thirdly, once extravasation has ceased, there is little or no potential rebleed, and therefore, reversal of heparin may be avoided. Nevertheless, if thrombin and/or occlusive coils are not available at the time, the use of fat and/or “makeshift measures” could be helpful. Fat embolization of persistent guidewire exit perforation is gaining popularity as it can be harvested from local subcutaneous tissue, it can be delivered by flushing saline solution through a microcatheter

at the perforation site or, as a new technique, by pushing effectively and more selectively a fat globule/cut off balloon assembly through the GEC, as described above.

Finally, if distal coronary perforations involve significant side branches or the distal parent vessel and there is no response to prolonged balloon inflation, this may trigger the impulsive reversal of both the anticoagulation and platelet inhibition. However, this decision should be carefully pondered as the risk of ongoing bleeding has to be balanced against the risk of acute vessel thrombosis: Heparin should not be fully reversed with the wire and balloon in the vessel or if stents have already been deployed as thrombosis of the whole vessel will lead to a higher mortality than the perforation. In fact, this was the further procedural error committed.

Accordingly, in our case, a typical type V perforation was caused by the hydrophilic guidewire and it occurred after stent deployment in the parent vessel. In such circumstance, reversal of heparin anticoagulation with protamine should have been avoided by using thrombin or coils and it would have represented the optimal solution considering a stent has already been deployed.¹⁰

4 | CONCLUSIONS

When dealing with complex interventions, the operator needs to be fully aware of a number of possible complications. Some are avoidable paying particular attention to the stent loss and the usage of the hydrophilic guidewire particularly prone to coronary perforations. In this regard, familiarity with devices and operators' special skills are required when using guiding extension catheters, stent or catheter fragment retrieving devices, and PTFE-covered stents.

Special consideration must be reserved to the occurrence of distal perforations, and a stent has just been implanted. In this case, coils represent the best option as it avoids reversal of heparin and is readily available.

Alternatively, the ingenuity to develop rapid solutions, even without dedicated devices, is sometimes a key element for the management of adverse events that may compromise patients' survival.

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CONFLICT OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

AM: wrote the case report. AT: assisted with editing. DP: assisted with editing. AC: assisted with editing.

ETHICAL APPROVAL

Appropriate consent has been obtained, prior to submission, for the publication of figures and data.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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