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Stent Crumpling as a Complication of Percutaneous Coronary Intervention, a Case Report and Literature Review

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ABSTRACT

Stent crumpling is a rare but potentially life-threatening complication of percutaneous coronary intervention (PCI). This report highlights a case of stent crumpling during a PCI procedure, its management, and the importance of advanced imaging techniques in diagnosing and addressing such complications. A 78-year-old man was admitted for elective PCI on the left anterior descending (LAD) artery following an acute anterior ST-segment elevation myocardial infarction (STEMI) treated with thrombolytic therapy. The patient exhibited significant ischemic changes on his electrocardiogram (ECG) and experienced persistent angina. During the PCI, two overlapping stents were deployed in the LAD. Post-dilation led to slow flow and thrombus formation in the LAD, rapidly progressing to cardiac arrest. Immediate resuscitation and intracoronary thrombolytic therapy were initiated. Intravascular ultrasound (IVUS) revealed stent crumpling, so the proximal stent folded within the vessel lumen. To solve this issue, the crumpled stent was crushed behind a newly deployed stent, followed by post-dilation, which restored TIMI flow grade III in the LAD.

1 | Introduction

One of the life-threatening complications of percutaneous coronary interventions (PCI) is stent failure. Although novel generations of drug-eluting stents, modern imaging techniques, and more potent antiplatelets have improved coronary interventions, stent failure has been reported in up to 15%–20% of PCIs [1]. The main causes of acute stent failure are stent thrombosis (ST) and stent fracture (STF) [2]. Another cause of acute stent failure is stent dislodgement, which can lead to coronary artery or systemic embolization, stent thrombosis, acute myocardial infarction (MI), and death [3, 4].

Stent malposition is primarily driven by mechanical factors such as stent underexpansion, excessive vessel calcification, and poor stent deployment techniques [5]. Severe inapposition can occur after the unintentional crossing of a wire behind the stent. These issues can lead to stent crumpling within the lumen and immediately progress to lethal acute stent thrombosis [6]. Epidemiologically, stent failure is associated with higher rates of adverse clinical outcomes, including myocardial infarction and the need for target lesion revascularization [7]. Advanced imaging techniques such as intravascular ultrasound (IVUS) and optical coherence tomography (OCT) are crucial in diagnosing and managing these complications. This case highlights the importance of intravascular coronary imaging (ICI) like IVUS or OCT for the detection of technical issues during the procedure and post-procedural monitoring.

Summary

- Though rare, stented crumpling can lead to severe complications.
- Advanced intracoronary imaging and meticulous procedural techniques are essential for diagnosis and management, significantly improving patient outcomes.
- This case underscores the need to identify this catastrophe promptly using intracoronary imaging and appropriate intervention.

2 | Case Presentation

2.1 | Case History/Examination

A 78-year-old man who experienced an acute anterior ST-segment elevation myocardial infarction (STEMI) four days prior was admitted. The patient had no past medical history of comorbidities. During his STEMI, he received thrombolytic therapy with recombinant tissue plasminogen activator (r-tPA). Despite optimal treatment, he experienced persistent angina. Upon admission, his vital signs were stable: blood pressure was 132/76 mmHg, heart rate was 88 beats per minute, and oxygen saturation was 96% on ambient air. His physical examination was unremarkable, with clear lung sounds on auscultation, no peripheral edema, and palpable regular peripheral pulses. A cardiopulmonary examination revealed a regular heart rhythm with no murmurs, rubs, gallops, or abnormal breathing sounds. Jugular venous pressure (JVP) was not elevated on his vascular examination. No bruits were heard over the carotid arteries. Capillary refill took less than 2 s.

2.2 | Differential Diagnosis, Investigations, and Treatment

Laboratory evaluations demonstrated that routine blood tests were within normal limits. His electrocardiogram (ECG) revealed significant ischemic changes, including Q waves, deep T wave inversion, and ST-segment alterations in the precordial leads. A transthoracic echocardiogram (TTE) showed regional wall motion abnormalities (RWMA), detecting hypokinetic segments in the anterior and apical walls, with a decreased left ventricular ejection fraction (LVEF) of 35%. There was no significant mitral regurgitation (MR) or pulmonary hypertension (PHTN).

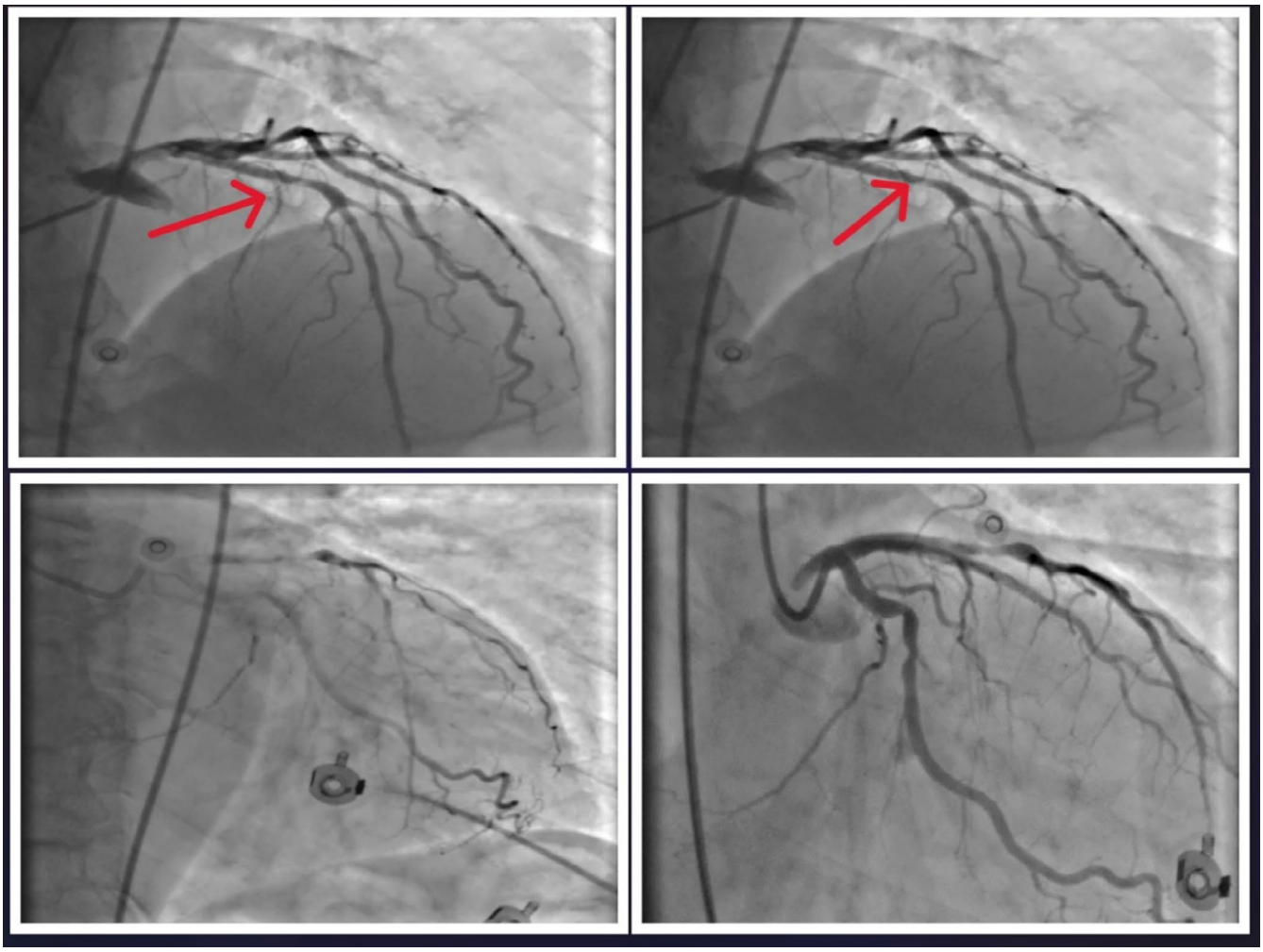

FIGURE 1 | Coronary angiography showed significant and hazy lesions in the proximal and midportion of the LAD (Red arrow). Therefore, PCI on the LAD was planned.

Coronary angiography was performed via right femoral artery access, revealing significant and hazy lesions in the proximal and mid-portion of the left anterior descending (LAD) artery (Figure 1). It was decided that we would proceed with ad hoc PCI during this session. However, the main obtuse marginal artery was scheduled for PCI in a subsequent session. Direct stenting was successfully performed using a Xience (Xpedition)3.0 × 33 mm stent for proximal LAD, followed by a Biomime Lineage 2.75 × 16 mm stent for the mid-portion of LAD, overlapping the proximal stent. Unfortunately, during the passage of the non-compliant balloon for post-dilation, the wire and guiding catheter were retracted once. However, the guiding catheter was re-engaged, and the wire (BMW Universal II) was passed through the target point again (Figure 1A,B).

After post-dilation, some filling defects were observed inside the stent, indicating stent thrombosis. Subsequently, slow flow was seen in the LAD, which rapidly progressed, and cardiac arrest occurred. Immediate defibrillation and cardiopulmonary resuscitation (CPR) were performed, and intracoronary thrombolytic therapy with Alteplase was administered. The patient was successfully resuscitated, and a subsequent dye injection revealed Thrombolysis in Myocardial Infarction (TIMI) flow grade II in the LAD. Given our concern about the events, intravascular ultrasound (IVUS) was employed to investigate the cause. IVUS revealed stent crumpling so that the proximal stent folded on one side of the vessel, causing one edge to float inside the lumen (Figure 2). The guidewire was exchanged from BMW to Sion Blue to correct the abluminal wire passage (Figure 3A,B). The crumpled stent was crushed behind a newly deployed Supraflex 4.0 × 20 mm stent, followed by post-dilation with a non-compliant Sapphire 4.0 × 10 mm balloon. Multiple inflations were performed to ensure complete expansion and proper stent apposition against the vessel walls. Final angiography confirmed TIMI flow grade III in the LAD, with adequate stent expansion and apposition confirmed by IVUS (Figure 4).

2.3 | Outcome and Follow-Up

The patient was transferred to the cardiac care unit (CCU) post-procedure for close cardiac monitoring and further management. Serial ECGs and cardiac enzyme measurements were

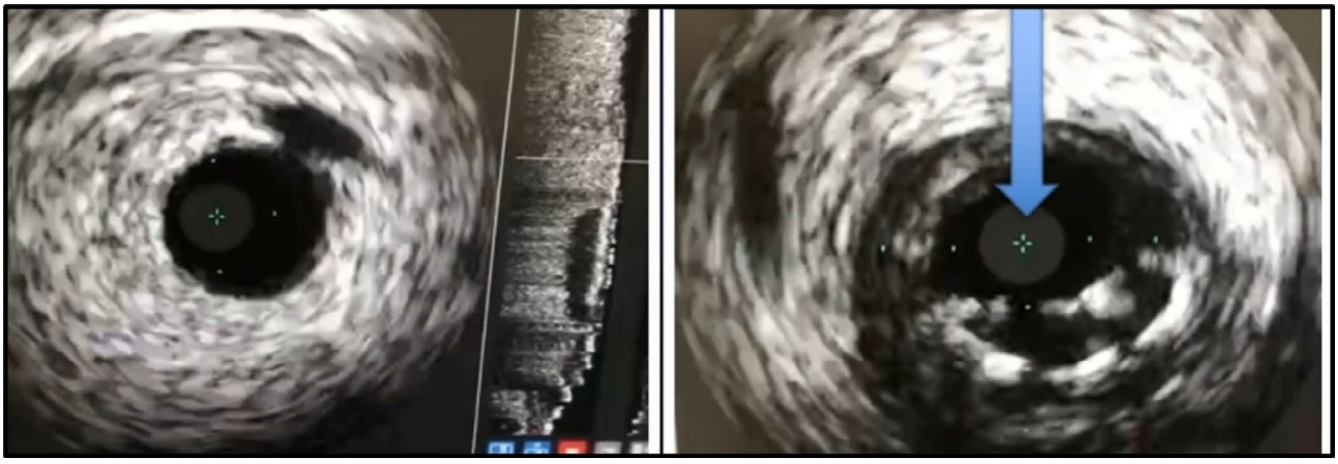

FIGURE 2 | Stent crumpling was seen so that the proximal stent was folded on one side of the vessel (one edge was floating inside the lumen).

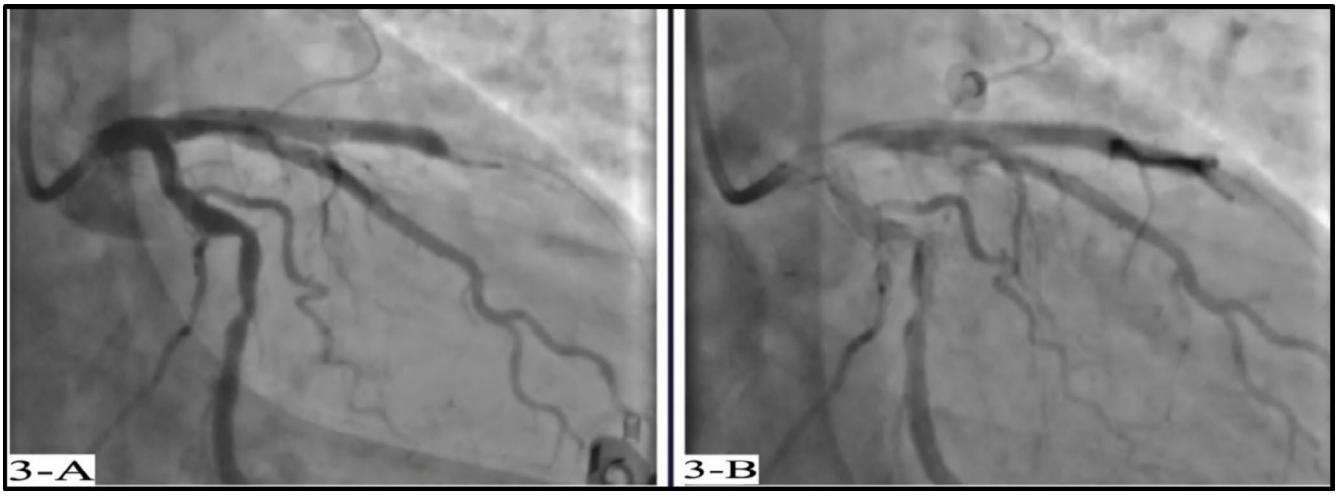

FIGURE 3 | (A, B) Following post-dilation, some filling defects seemed to be inside the stent (stent thrombosis), then slow flow was seen in LAD, which worsened rapidly.

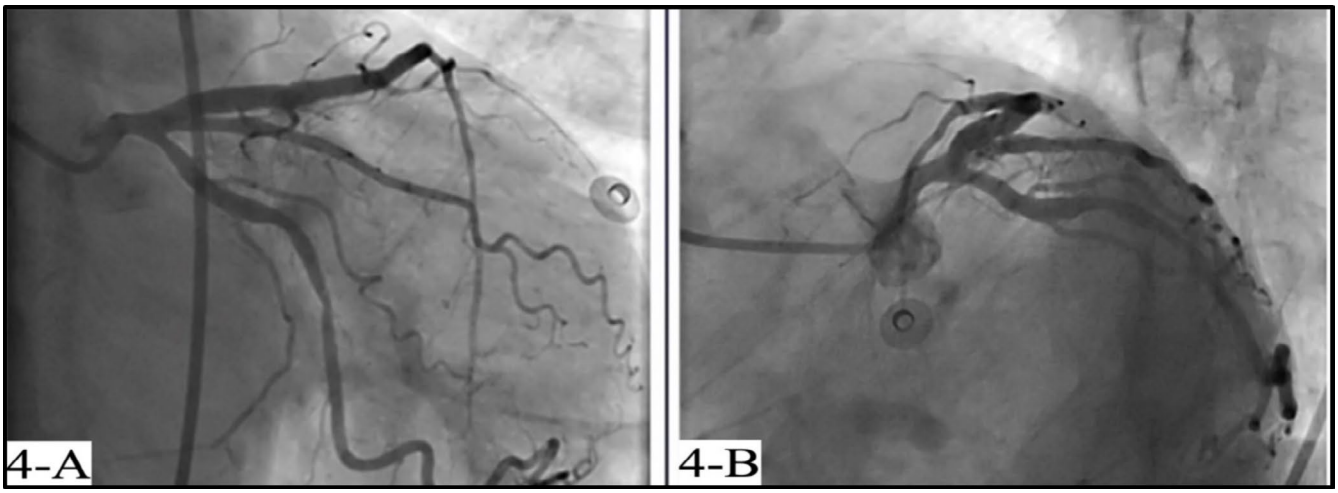

FIGURE 4 | (A) Angiography after new stent deployment (Supraflex 4 *20) and new post-dilation by non-compliant balloon (Sapphire 4*10). (B) Angiography confirmed TIMI flow III in LAD, and adequate expansion and apposition of the stent were confirmed.

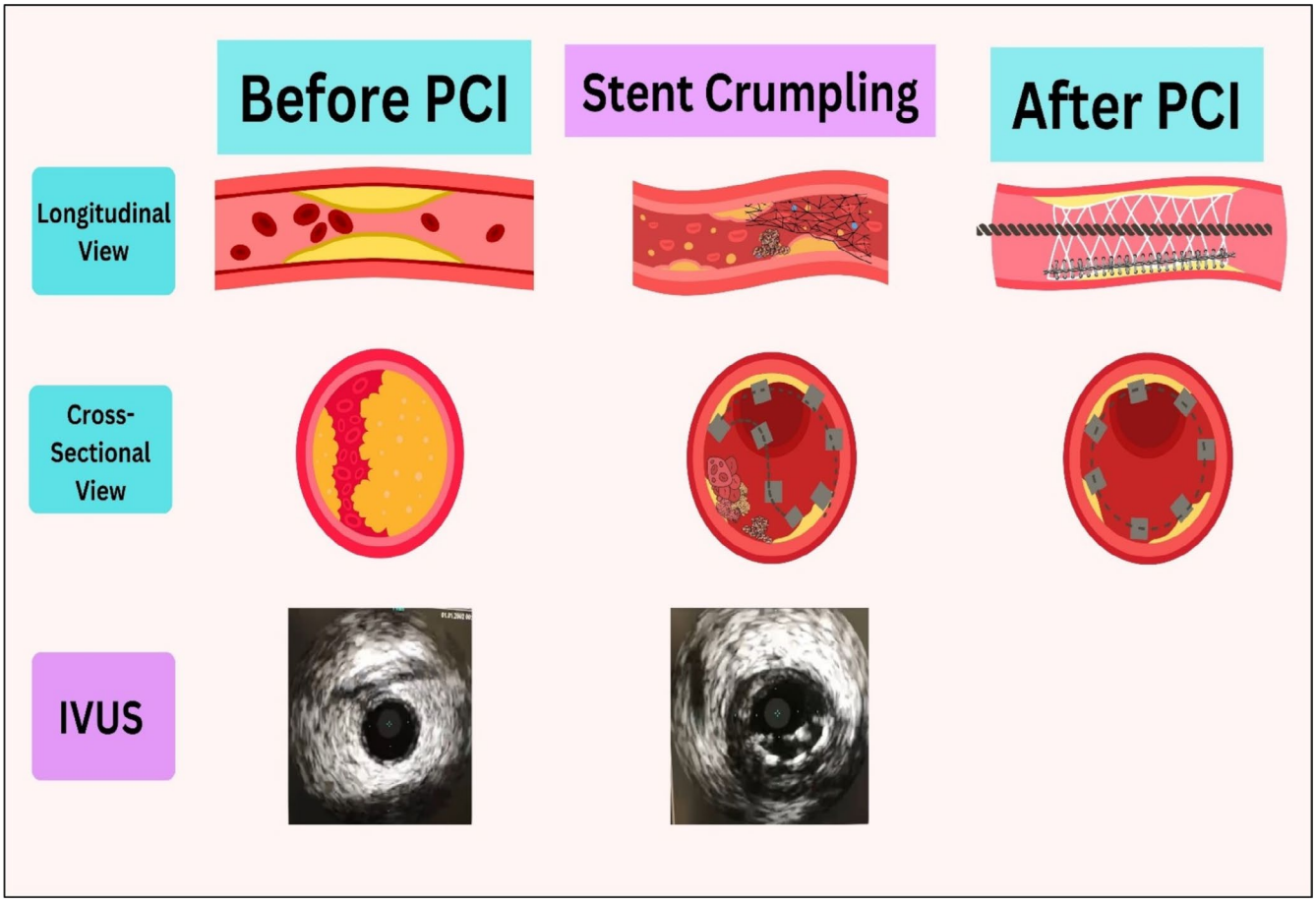

FIGURE 5 | (Graphical abstract): The graphical description of stent crumpling and its management.

planned to evaluate potential recurrent ischemia and assess myocardial damage. Four days after the procedure, the patient was discharged in stable condition with dual antiplatelet therapy (aspirin 80 mg and clopidogrel 75 mg daily). He was followed for several months, during which he remained asymptomatic with no further cardiac complaints. A graphical abstract of this event is provided in Figure 5.

3 | Discussion

This case report presents the complex and challenging scenario of a 78-year-old male whose treatment was complicated due to a rare event, stent crumpling, during PCI for a significant culprit lesion in the LAD. This case highlights the probability of stent thrombosis caused by severe iatrogenic inapposition during the attempt

TABLE 1 | Literature review table.

Authors and YOP	Age and gender	Presentation	Clinical progression
Arous S. et al. 2024 [6]	64-year-old man	**Hx:** Angioplasty of mid and distal LAD with two DES; distal LM stenosis. Symptoms initiated with retrosternal chest pain two months prior to his presentation. **PH/E:** Persistent Canadian class III angina; BP 128/72 mmHg, pulse 90 bpm, SpO2 96%. **ECG**: RSR, anterior Q waves **LAB:** Unremarkable **Imaging**: Echo: IHD, anterior and apical hypokinesia, LVEF 50%, normal LV filling pressure, no MR or Pulmonary Hypertension	**DX:** Stent dislodgement during PCI in LMCA **TX:** Angioplasty via right femoral artery; PCI with DES; stent retrieval with balloon expansion technique **Prog:** Complete resolution of chest pain; no restenosis
Kalavakunta J et al. 2021 [17]	74-year-old woman	**Hx:** Electively admitted for PVI, CAD with RCA stent one year ago, HTN, HLD, persistent AF **LAB:** Not specified **Imaging:** TEE showed 0.7 × 1.35 cm echogenic structure from RCA ostium; CT confirmed RCA stent protruding into the aorta	**DX:** Protruding RCA stent into the aorta **TX:** PVI procedure completed uneventfully **Prog:** No clinical symptoms or structural damage
Meng L. et al. 2022 [18]	55-year-old man	**Hx:** HTN for three years, presented with back pain, nausea, discomfort, and fatigue **PH/E:** No abnormalities **LAB:** significantly elevated Troponin (I or T or high sensitivity if mentioned) level and CK-MB **ECG:** RSR, inferior MI, ST-segment depression Coronary angiography: 60%–70% stenosis in proximal and a complete occlusion in middle RCA; IVUS: severe CAS	**DX**: Acute MI, coronary artery spasm, AST **TX:** PCI with balloon angioplasty and DES insertion; treated with aspirin, clopidogrel, atorvastatin, and diltiazem **Prog**: effective medical management and no further cardiac events
Lu M. et al. 2023 [19]	73-year-old man	**Hx:** HTN, dyslipidemia, CAD with PCI 14 and 10 years, unstable angina **PH/E:** details not provided **LAB:** Not specified **RAD:** CAG showed 80%–95% stenosis from proximal to middle LAD and 90% stenosis in proximal RCA; fluoroscopy revealed a proximal segment of the stent in LMCA and a distal segment floating in the aorta	**DX:** Off-wire dislodged coronary stent with proximal segment lodged in LMCA and distal segment floating in the aorta **TX:** PCI for RCA lesion without complications; attempted retrieval of dislodged stent; additional stenting and balloon angioplasty performed for LAD and LMCA. **Prog:** No vascular injury observed; event-free for over one year
Azarisman S. et al. 2011 [11]	56-year-old, male	**Hx**: Type 2 DM, HTN, HLD, non-smoker, no family history of CAD, Presented with ischemic chest pain **PH/E**: acute ST-elevation inferior MI **LAB**: significantly elevated CK. **ECG**: NLLVEF (56%), hypokinetic inferior walls Coronary angiogram: dominant, ectatic RCA with discrete proximal and distal lesions	**Dx**: Wire-induced stent crumpling in RCA during PCI **Tx**: Thrombolysis with streptokinase; angioplasty **Prog**: Asymptomatic with good functional status

(Continues)

TABLE 1 | (Continued)

Authors and YOP	Age and gender	Presentation	Clinical progression
Egbuche O. et al. 2021 [20]	44-year-old female	**Hx:** CABG for flow-limiting proximal LMCA stenosis one year ago; occluded bypass vein graft; persistent Canadian class III angina CAG: short, large-diameter LMCA, 50%–60% ostial stenosis; angiogram post-retrieval showed good patency of bilateral iliofemoral arteries without complications	**DX:** Stent dislodgement and entrapment in RCFA during PCI for LMCA stenosis **TX:** Predilation with a compliant balloon; stent dislodgement managed by trapping the stent with a balloon and retrieving via contralateral femoral access; **Prog:** No complications; asymptomatic at follow-up

Abbreviations: ACS, acute coronary syndrome; AF, atrial fibrillation; BP, blood pressure; bpm, beats per minute; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CK, creatine kinase; CK-MB, creatine kinase-MB; CT, computed tomography; DES, drug-eluting stent; DM, diabetes mellitus; DX, diagnosis; Echo, echocardiogram; ECG, electrocardiogram; FFR, fractional flow reserve; HLD, hyperlipidemia; HTN, hypertension; Hx, history; IHD, ischemic heart disease; IVUS, intravascular ultrasound; LAB, laboratory results; LAD, the left anterior descending artery; LIMA, the left internal mammary artery; LM, left main; LMCA, left main coronary artery; LVEF, left ventricular ejection fraction; MI, myocardial infarction; MR, mitral regurgitation; NL, normal; PCI, percutaneous coronary intervention; PH/E, physical examination; Prog, prognosis; PVI, pulmonary vein isolation; RAD, radiology; RCA, right coronary artery; RCFA, right common femoral artery; RSR, regular sinus rhythm; SpO2, oxygen saturation; TEE, transesophageal echocardiogram; TX, treatment; YOP, year of publication.

for post-dilation. It also emphasizes the critical role of intracoronary imaging, including IVUS, in managing these complications.

Acute coronary stent thrombosis can be categorized into several types based on the mechanism of occurrence [8]. These complications often require further intervention to be managed successfully to minimize stent failure and enhance patient outcomes. Longitudinal stent deformation involves the compression or elongation of the stent along its length, usually due to procedural forces or intrinsic design weaknesses, resulting in complications like stent thrombosis. On the other hand, resultant plaque prolapse involves the protrusion of plaque material through the stent struts into the lumen, increasing the risk of stent thrombosis and myocardial injury [5].

In the left main, stent thrombosis, malposition, and stent struts crossing an ostial side branch were identified as significant predictors of stent failure and subsequent events, highlighting the importance of imaging-guided PCI. Understanding these mechanisms is essential for improving procedural techniques to minimize mechanical complications during stent implantation and its resultant fatal conditions [9]. Failure to deploy stents properly (for any reason) is a common problem, occurring in 8.3% of cases [10]. Stent crumpling, as observed in this patient, is a recognized but uncommon complication of PCI. It typically occurs due to mechanical forces exerted on the stent during deployment or post-dilation, particularly in complex lesions characterized by heavy calcification and tortuosity [11]. In the present case, the crumpling happened during post-dilation, which we noticed when we faced resistance in passing the non-compliant balloon. During this process, the wire unintentionally crossed the space behind the stent, and we did not notice the incident. Inflation of the balloon caused the detachment of the stent from the coronary artery wall, and the stent crumpled unilaterally. The clinical consequences of stent crumpling are severe, often leading to acute complications such as stent thrombosis, acute myocardial infarction, and even patient death [12]. In this case, the patient developed thrombosis formation and resultant no-reflow in the LAD, progressing rapidly to cardiac arrest. Early stent thrombosis (ST) has been linked to increased mortality rates both during hospitalization and within the first 30 days following primary PCI [13].

Effective management of stent crumpling involves prompt identification and intervention. Advanced imaging techniques such as IVUS and OCT are essential for diagnosing stent-related complications with greater sensitivity than conventional angiography [5]. In this case, IVUS played a pivotal role in visualizing stent deformation and guiding the appropriate therapeutic strategy. Once stent deployment fails, retrieval techniques such as the small-balloon method, two-wire technique, and loop snare can be used, or the stent can be crushed. These methods are typically employed for undeployed stents. For distorted, deployed stents, options are more limited, but the success rate of the crushing technique appears favorable [11].

Preventive strategies can reduce the risk of complications caused by the unintentional passage of the wire from the space between the stent and the lumen wall. These strategies include selecting the appropriate catheter type and size, ensuring thorough predilatation if required, considering the severity of the

lesion, using buddy wires, and maintaining the guidewire's position throughout the procedure [11]. Incorporating a preventive strategy for stent crumpling involves careful fluoroscopic examination. This approach emphasizes the importance of advanced imaging techniques to detect and manage complications like stent crumpling early, thereby improving patient outcomes [9]. Therefore, it is crucial not to lose control of the wire before inflating the balloon. Otherwise, there is a risk of the wire crossing extraluminally or abluminally.

There are studies that have shown that adequate stent expansion, particularly complete apposition, is associated with better acute and long-term stent patency and clinical outcomes [8, 14]. Ensuring complete lesion coverage and avoiding landing zones within areas of residual plaque burden is critical to reducing the risk of stent thrombosis and restenosis [8].

This case highlights the critical role of IVUS in diagnosing and guiding the management of stent-related complications. The utilization of IVUS has been proven to be a game changer in managing and preventing stent-related complications such as stent crumpling and thrombosis. IVUS provides high-resolution imaging, allowing for a detailed assessment of stent placement and interaction with arterial walls, identifying issues like underexpansion and malposition that traditional angiography often misses. Studies have shown that IVUS-guided PCI results in better stent expansion and apposition, reducing major adverse cardiovascular events (MACE). Procedural enhancements facilitated by IVUS, such as more effective post-dilation and targeted thrombosis suction, significantly mitigate the risks associated with stent thrombosis and crumpling. Thus, IVUS is indispensable in ensuring optimal stent deployment and improving patient outcomes in PCI procedures, particularly in complex cases [15, 16]. We have provided similar cases of stent failure in Table 1.

Author Contributions

Maryam Mehrpooya: conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original draft, writing – review and editing. **Hamed Vahidi:** conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original draft, writing – review and editing. **Maryam Taheri:** conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original draft, writing – review and editing. **Pouya Ebrahimi:** conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing – original draft, writing – review and editing.

Consent

Written informed consent was obtained from the patient for this study based on the patient's consent journal's policy.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Further data will be provided by the corresponding author if there is a reasonable request.

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