Pak Heart J 2023:57(01)
ISSN:0048-2706 E-ISSN:2227-9199

Lethal Left Anterior Descending Perforation in Anterior Myocardial Infarction During Primary Percutaneous Coronary Intervention. A Rare Case Finding and Literature Review

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Abstract
Introduction: Artery perforation during Percutaneous Coronary Intervention (PCI), is a rare but potentially life-threatening complication that may occur during cardiac catheterization procedures.

Case Illustration: A 57 years old male with chest pain sought for further medical care due to persistence in chest pain. The clinical case shown is a match for acute coronary syndrome (ACS)**.** During angiography study, perforation occurred seemingly radiates towards distal with every intervention given to stop perforation in the proximal.

Discussion. It is important to assess ACS at once to reduce myocardial death. The potential perforation evident in our observation from the replay may be attributed to severe calcification at the lesion, potentially fostering cavitation-induced plaque rupture, collateral perforation, indicating a blood supply from a ruptured collateral artery, guidewire dissection of subintimal, causing the wire to enter the subintimal space rather than the true lumen of the blood vessel, and may create a small dissection in artery and lead to rupture. Employing an angiographic categorization system proves to be of significant value in guiding the treatment strategy.

Keyword: Lethal perforation, Percutaneous Coronary Intervention (PCI) complication, Left Anterior Descending Perforation

Introduction
Artery perforation during Percutaneous Coronary Intervention (PCI), is a rare but potentially life-threatening complication that may occur during cardiac catheterization procedures. This situation arises when the coronary artery's wall is inadvertently punctured or torn, leading to the leakage of blood into the surrounding tissue layers. Incidence rate of perforation occurred in 70 of 10,278 PCIs between 2014 and 2019.(1) Timely recognition of this complication is paramount, as it can result in hemodynamic instability and other serious consequences if left untreated. Physicians and interventional cardiologists must be well-prepared to address artery perforations, employing various techniques such as balloon tamponade or stent graft placement to seal the perforation and restore normal blood flow. Close monitoring and rapid response are essential in managing these situations to minimize the risk of further complications and ensure the best possible outcomes for the patient. Continuous research and advancements in interventional cardiology techniques contribute to improving the management of artery perforations during PCI, enhancing patient safety and overall procedural success. However, the best recommendation is still ambiguous.We report a case of acute ST-elevation myocardial infarction (STEMI) in a 57-year-old male with chest pain and Left Anterior Descending Artery perforation during emergency

catheterization angiography and received expectant management by the interventionist cardiology service.

Clinical Case

We report a case of acute ST-elevation myocardial infarction (STEMI) in a 57-year-old male with chest pain and Left Anterior Descending (LAD) artery perforation during emergency catheterization angiography. He was referred from lower facility care due to myocardial infarction and cardiogenic shock, diagnosis was established in the previous hospital from electrocardiography, elevated cardiac enzyme (CKMB was 60) and hypotension supported by two vasoconstrictors. Onset of chest pain was felt 3 days ago and the patient sought for further medical care due to persistence pain. After some consideration, the patient was sent to our hospital for Percutaneous Coronary Intervention (PCI). Patient was a heavy smoker. Physical examination when arrived at our Emergency Room, he had blood pressure 90/60 mmHg, heart rate of 116, respiratory rate of 24, saturation of 96% with nasal cannula.

On admission the patient received Acetylsalicylic acid 160 mg, Clopidogrel 300 mg, Atorvastatin 40mg by oral route and intravenous Heparin 5000 IU was administered in the previous facility health care. He was also given continuous intravenous Norepinephrine 0,2 mcg/kg/min and Dobutamine 10 mcg/kg/min due to hypotension (previous record of blood pressure was 60/40 mmHg).

The initial electrocardiogram revealed HR of 115 bpm, sinus rhythm with elevation lead V1 to V4 indicating anterior wall infarction.

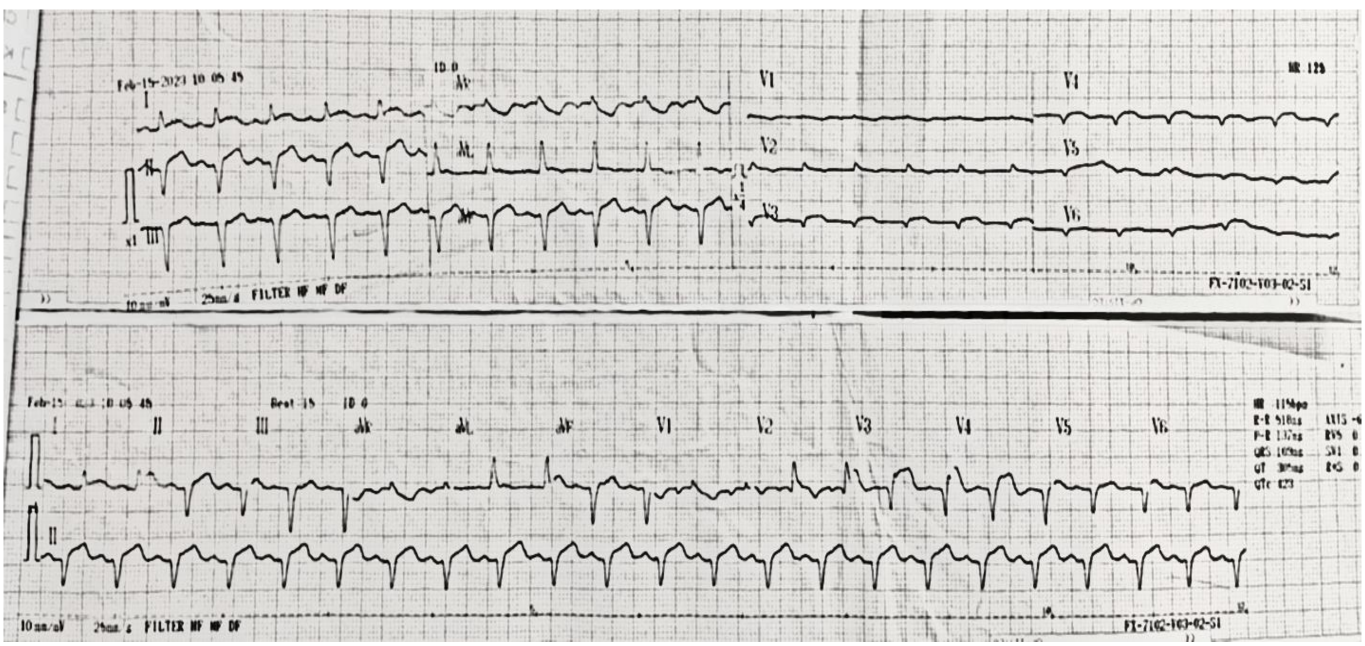

Fig 1. ECG: sinus tachycardia and anterior wall infarction

We stopped the vasoconstrictor and added Ticagrelor 180 mg and acetylsalicylic acid 80 mg for pre PCI medication and then transferred to catheterization.

Coronary Angiography Study

Emergent catheterization through the right brachial artery approach showed total occlusion in the proximal left anterior descending (LAD) artery (Fig 2).

Fig 2. Coronary angiography showed total proximal occlusion in LAD.

Angioplasty was performed and guidewire was approached to the occlusion to open the narrowing vessel (Fig 3). Guidewire was able to puncture the thrombus to distal LAD, balloon SC 2,0/15 mm was inflated to widened the vessel. The first balloon angioplasty measure showed a slight indentation in proximal narrowing point, indicated the presence of a firm and solid occlusion at the proximal LAD.

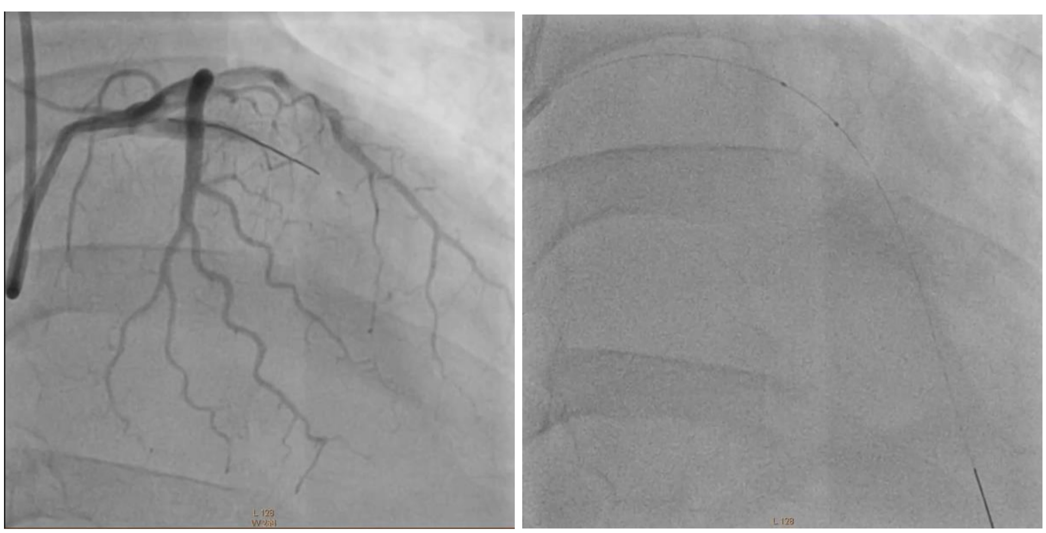

Fig 3. Guidewire was able to puncture the thrombus to distal LAD (Left). Guidewire approached distal occlusion to open the narrowing vessel (Right).

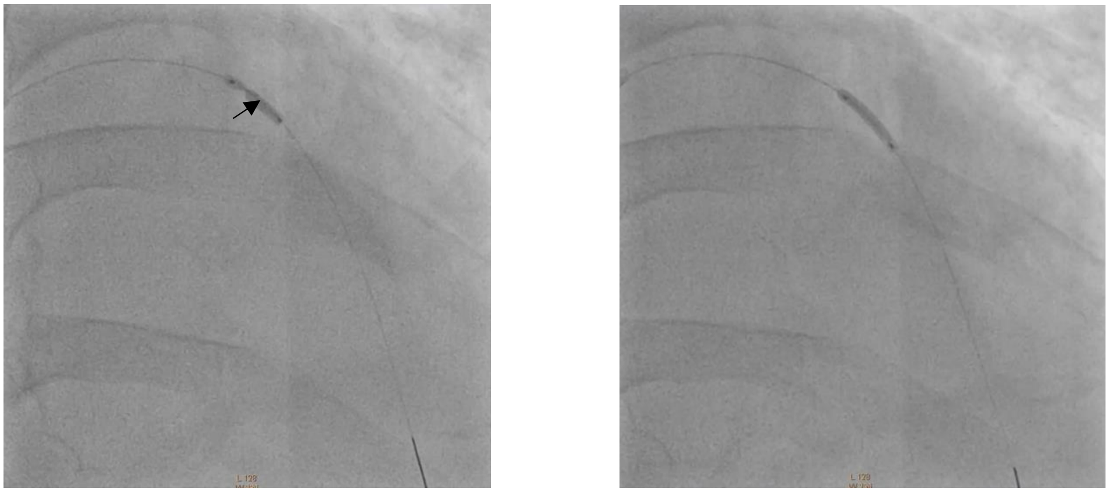

Fig 4. Balloon angioplasty showed a slight indentation in proximal narrowing point (arrow).

The first contrast ejection showed sudden contrast leak, leading to perforation of proximal LAD showed contrast extravasation through >1 mm perforations indicating coronary perforation type III by modified Ellis classification (Fig 5). Our interventionist immediately inflated balloon to tamponade the bleeding site for 5 minutes hoping that the perforation could be resolved (Fig 6), and placed one stent DES 2,5/20 mm to the site of perforation.

Fig 5. Proximal flow showed contrast leak. Coronary perforation type III by Ellis classification.

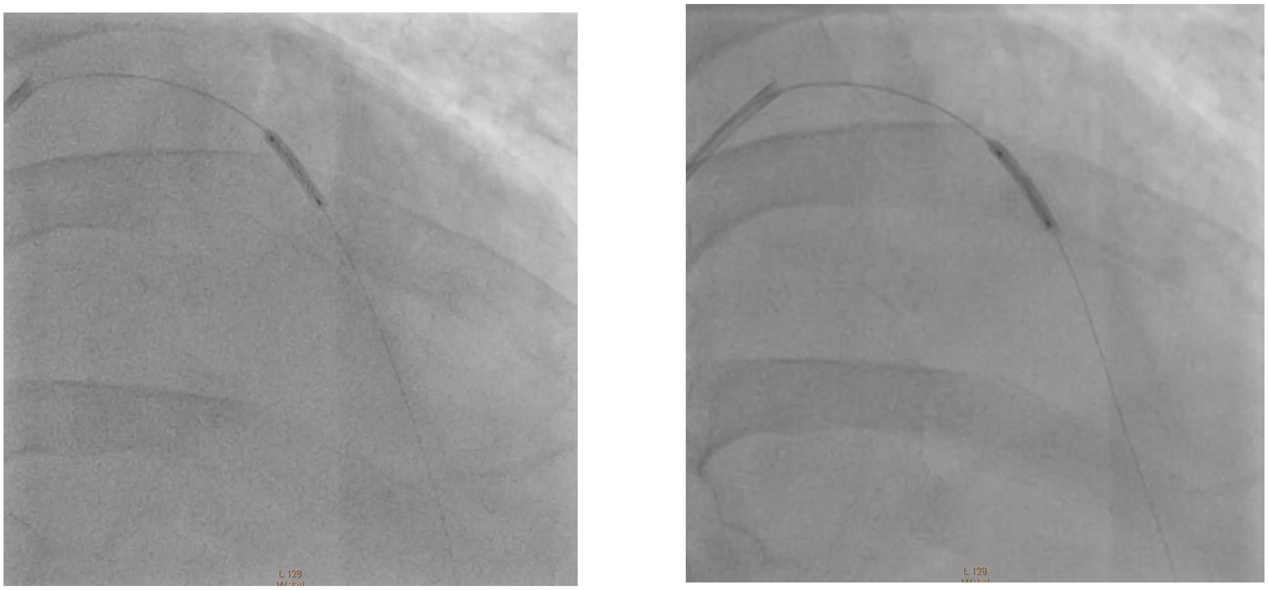

Fig 6. Inflated balloon for 5 minutes to tamponade the bleeding and placed one stent DES 2,5/20 mm to the site of perforation.

After the stent was deployed, contrast was reinjected to assess the vessel's condition and observed perforation in the distal vessel where the stent placed, the perforation shifted slightly towards the distal from the initial perforation.

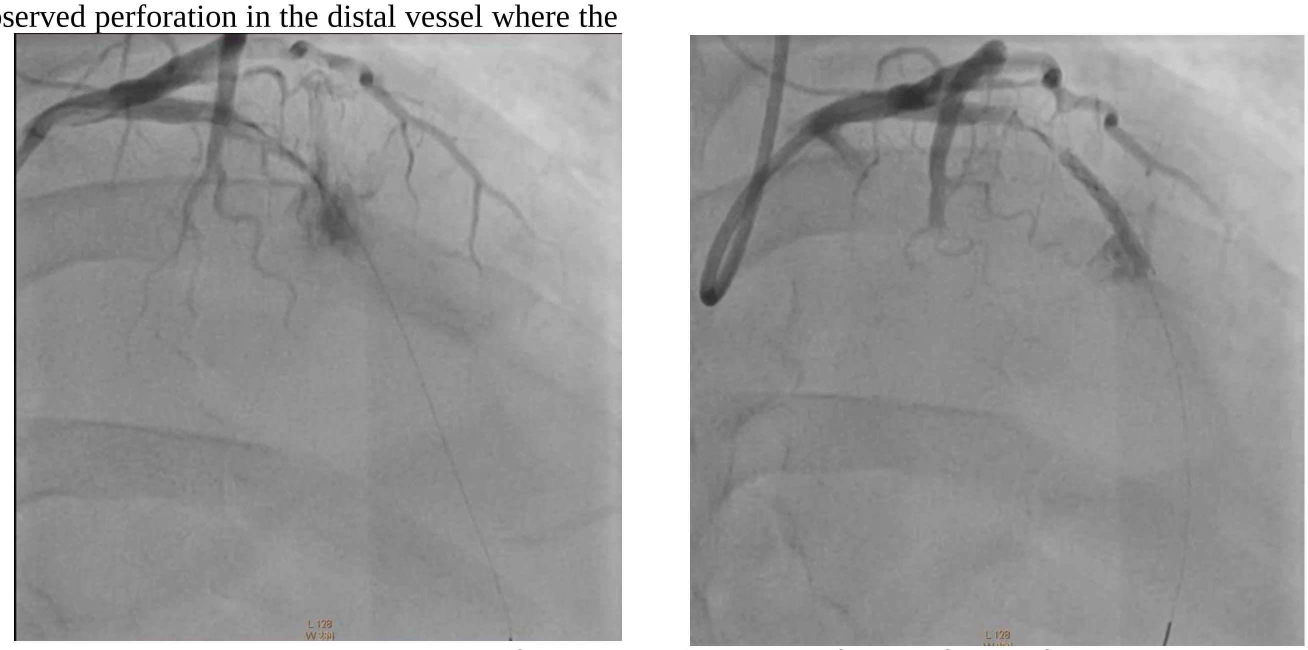

Fig 7. Comparison LAD angiography before stent deployment (left) and after the first stent deployment (right). The leak seemed to shift to the distal of first point.

Balloon was again inflated for 5 minutes to tamponade the bleeding, followed by advance of the second stent DES 2,5/20 mm to the site of the new perforation, overlapping the first stent in proximal LAD and slightly distal from the rupture. Multiple measures to tamponade bleeding by inflating balloon were done and leak seemed to reduce, with extraluminal crater without linear extravasation of contrast suggesting dissection, indicating coronary perforation type I by Ellis classification (Fig 9).

Fig 9. Angiography after deployment of overlapping 2 stents DES 2,5/20 mm and multiple balloon inflations.

We tamponade for a minute to observe the patient's response, but the patient appeared agitated. We evaluated angiography and observed another leakage from the mid to distal LAD, perforation showed coronary perforation type III "cavity spilling" by Ellis classification and it appeared as "firework-like appearance" as there was perforation along the LAD artery from mid to distal (Fig 10). The patient went into ventricular tachycardia with no pulse. We initiated the cardiac arrest algorithm and intubation, after 2 cycles, the patient achieved Return of Spontaneous Circulation (ROSC). We proceeded with intervention, inflating balloon for 5 minutes to tamponade the bleeding. We deployed the third stent (DES 2.5/20 mm) at the bleeding site in the mid LAD and performed balloon tamponade in the proximal LAD simultaneously.

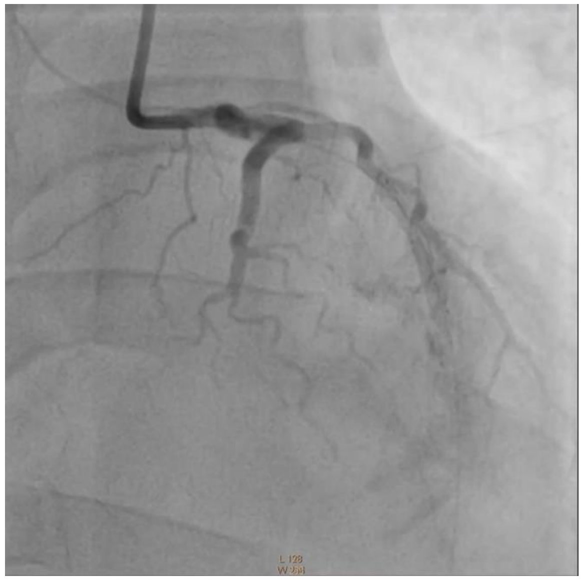

Fig. 10. Perforation from the mid to distal LAD. Type III "cavity spilling" by Ellis classification

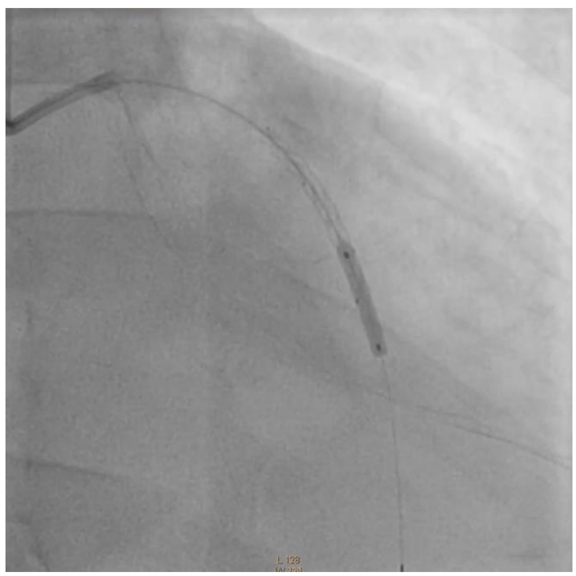

Fig 11. Deployment of the third stent (DES 2.5/20 mm) at the bleeding site in the mid LAD

Unfortunately, the perforation seemed to worsen, perforation overlapping the third stent that was installed to initially stop the bleeding and it seemed radiate and move distally with each intervention measures.

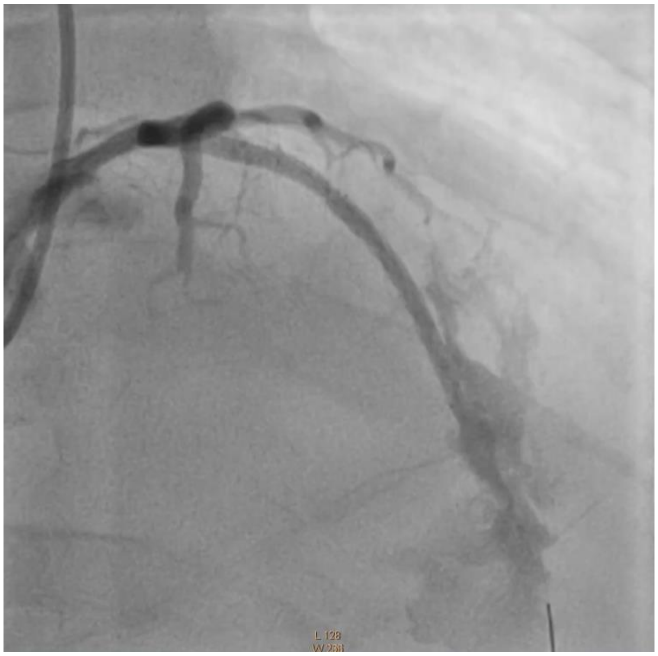

Fig 7. *Firework-like appearance* – Long perforation of LAD

However, a firework-like appearance was evident in the last angiography before the patient went into asystole. Despite various manipulation measures, the perforation did not resolve, leading to inevitable cardiac tamponade. Within 30 minutes manipulation, the patient showed unresponsive to treatment, and unfortunately, the patient succumbed.

Literature Review

Clinical case reports of a 57 years old male with chest pain and a heavy smoker, sought for further medical care due to persistence in chest pain. The clinical case shown is a match for acute coronary syndrome (ACS). It is important to assess ACS at once to reduce myocardial death. Parameters in which every clinician needs to manage is precise anamnesis and clinical examination. Electrocardiogram (ECG) is an initial examination that is swift, easy and non-invasive to establish the prompt diagnosis of myocardial ischemia and the provision of primary treatment to prevent the continuation of myocardial death.

The potential perforation evident in our observation from the replay may be attributed to severe calcification at the lesion, potentially fostering cavitation-induced plaque rupture. The second factor involves collateral perforation, indicating a blood supply from a ruptured collateral artery. Next one is may due to guidewire dissection of subintimal, causing the wire to enter the subintimal space rather than the true lumen of the blood vessel, and may create a small dissection in artery and lead to rupture.

Percutaneous coronary intervention (PCI) stands as the foremost procedure for the management of ST-elevation myocardial infarction (STEMI), as it swiftly restores blood flow to the affected coronary artery, minimizing heart damage and improving patient outcomes. It is a minimal invasive procedure, aims to alleviate the constriction or blockage of the coronary artery and enhance blood flow to the ischemic tissue. Typically, this is accomplished through various techniques, such as balloon dilation of the narrowed segment or placement of a stent to maintain artery patency.(2)

While PCI is generally considered a safe procedure, it does carry some potential complications. These complications may include bleeding, vascular complications such as arterial dissection, perforation, or closure, arrhythmias etc. These complications may require additional treatment or surgery. However, these complications are relatively uncommon, and the benefits of PCI often outweigh the risks, especially in cases of acute coronary syndromes or significant coronary artery disease.(3)

The occurrence of spontaneous coronary artery rupture and coronary perforation during percutaneous interventions is infrequent but potentially life-threatening, often requiring emergency surgery. Coronary perforation is a recognised complication of PCI with an incidence of around 1 in 250 procedures (0.39%). (4)

The occurrence of acute perforation resulting from catheterization varies depending on the utilized device used. Conventional balloon angioplasty has an approximate range of 0.1 to 0.2%, while modern tools such as directional atherectomy, rotablation, excimer laser angioplasty, or extraction atherectomy might result in significantly elevated rates, reaching up to 3%.

To address acute coronary perforations during catheterization procedures, interventional strategies for nonsurgical treatment have been developed. The advent of coronary stent-grafts allows for a percutaneous resolution of acute perforations, preserving vessel patency. While iatrogenic perforations in the catheterization laboratory can be promptly managed on-site, rupture of pre-existing yet potentially undiagnosed coronary pathology often leads to significant diagnostic delays, resulting in severe clinical events like myocardial infarction, cardiac tamponade, malignant arrhythmias, or sudden death. Considering this, it may be prudent to consider prophylactic treatment for coronary conditions prone to rupture, even if diagnosed incidentally. This preventive approach can be achieved through cardiothoracic surgery or, when appropriate, interventional therapy.(5)

During the period from 2014 to 2019, a total of 70 instances of perforation were observed out of 10,278 percutaneous coronary interventions (PCIs) (0.7%). The average age of the patients was 71 ± 12 years, 66% male, and 30% having a history of prior coronary artery bypass graft surgery. Among the cases of perforation, chronic total occlusions were prevalent in 33% of cases, moderate/severe calcification in 66%, and moderate/severe tortuosity in 41%.(1)
In our case, it was 57 years old male with total occlusion and severe calcification, having high probability of perforation.

In a meta-analysis conducted by Mikhail et al. comprising 4397 cases, they meticulously recorded the location of coronary perforation. The left anterior descending (LAD) artery, which includes the Left Main Coronary artery (LMCA), emerged as the most frequently affected site, making up 40.3% of the perforations (95% CI 32.8% to 48.3%). Roughly 54.2% of the perforations were observed in either the left circumflex artery or the Right coronary artery. A mere 6% of the documented cases reported perforations within a coronary bypass graft. In our specific case, the perforation was noted in the LAD artery.(4)

The risk factors have been observed to have a direct correlation with the complexity of coronary artery disease. These risk factors can be divided into the following groups:

A. Factors beyond control:
- Advanced age
- Female gender
- History of prior coronary artery bypass graft (CABG)
- Administration of clopidogrel

B. Factors that can be modified:
- Hypertension
- Peripheral Artery Disease
- Congestive Heart Failure
- Lower Body Mass Index
- Reduced Creatinine Clearance

C. Risk factors associated with coronary structure and catheterization:
  - Complex coronary lesions (ACC/AHA Type B2, C)
  - Chronic total occlusions, heavily calcified lesions, angulated, tortuous lesions, narrow coronary arteries
- Intensive use of oversized balloons and stents
- Application of atheroablative tools and hydrophilic guidewires.

Ellis and colleagues proposed an angiographic classification system for PCI perforations, comprising three types, subsequent study evaluated the in-hospital outcome of patients with coronary perforation and concluded that those with large perforations (type III) had a mortality rate of 21.4% vs. ≤ 1%, when compared to type I or II perforations (6) (7)

a) Type I extraluminal crater without any contrast extravasation
b) Type II contrast extravasation limited to “blushing” in the myocardial or epicardial fat
c) Type III contrast extravasation through frank (>1 mm) perforations or type III “cavity spilling” extravasation into either the left ventricle, coronary sinus, any of the cardiac chambers or the pericardium.

Modified Ellis classification for coronary perforations:
Type I : Extraluminal crater without linear extravasation of contrast suggesting dissection
Type Il : Pericardial or myocardial blush, with exit orifice < 1 mm
Type Ill : Clear contrast extravasation into the pericardium through orifice ≥ 1 mm in diameter
Type IV : Perforation with spillage of contrast directly into the left ventricle, coronary sinus or other vascular chamber, excluding the pericardium
Studies earlier providing data on the management of coronary perforations:

1. Ensure hemodynamic stabilization and support by provide sufficient blood pressure and volume assistance through intravenous fluids, blood transfusions, auto transfusions, vasopressors, or atropine administration in the occurrence of bradycardia. Call for help, including an echocardiography sonographer, surgeon, or anaesthesiologist. Prepare for a prompt pericardiocentesis if faced with cardiac tamponade. Provide percutaneous hemodynamic assistance such as intra-aortic balloon pump, impella for cases of shock.(8)

2. Surgical intervention was necessary for approximately 16.6% of patients with coronary artery perforations (CAP) (95% CI 10.94% to 24.4%). Surgical reports include simple suturing of the perforation, ligation of bleeding vessels, pericardial patch applications to obtain haemostasis, use of surgical glues, coronary artery bypass grafting with and without endarterectomy, stent removal, or vein patch.(9)

3. Balloon tamponade showed half of the cases of coronary perforation were successfully treated using percutaneous methods (28.7% (95% CI 17.2% to 43.7%)).

4. Installation of a covered stent (24.7% (95% CI 14.7% to 38.6%)). The implantation of coronary stent-grafts holds promise as the preferred treatment option due to its technical ease, safety, and shorter hospital stays.

5. Some additional interventions also include local injection of thrombogenic molecules, placement of micro-coils, and transcatheter embolization with autologous blood clot or glue.

6. Pericardiocentesis, when performed with the guidance of echocardiography or fluoroscopy in either the catheterization laboratory or the intensive cardiac care unit, can be carried out safely. It serves as both a definitive treatment

option and a bridging treatment to stabilize the patient before considering open surgical intervention. In a retrospective study conducted by Fejka et al, which involved 31 cases of tamponade with PCI complications, 61% of the cases were successfully treated solely with pericardiocentesis, while 39% necessitated subsequent surgical intervention.(10,11)

7. Conservative management in about 9.7% of perforations (95% CI 5.2% to 17.4%), without percutaneous or surgical intervention proved to be effective as the sole treatment approach by giving reversal of anticoagulation. Delaying heparin reversal until after equipment removal is advisable to avert potential vessel thrombosis. In certain instances (approximately 47% of the perforations identified), no targeted treatment may be necessary, but vigilant monitoring is crucial, considering that complications may arise within several hours, particularly in cases involving distal-vessel perforations. Transfusion of blood products, close monitoring with echocardiography, and percutaneous pericardial drainage if indicated. , local injection of thrombogenic molecules, placement of microcoils, and transcatheter embolization with autologous blood clot or glue.(1,12,13)

However, in 20.3% of the analysed patients, the final treatment method for coronary artery perforation remained uncertain. Among the cases where the final treatment modality was ascertainable, covered stents were utilized in 31% of cases, balloon tamponade in 36%, surgical intervention in 21%, and medical management in 12%.

The prognosis of coronary artery perforation (CAP) varies based on its severity. For Ellis types I and II, conservative management is typically employed, leading to spontaneous resolution in many cases or the development of pseudoaneurysms. However, a minority of patients may experience delayed pericardial effusions, making serial echocardiography essential within the initial 48 hours of CAP diagnosis. On the other hand, Ellis type III poses a considerable mortality risk if subsequent cardiac tamponade is not addressed promptly with the measures mentioned above.

Conclusion

In brief, it is of great importance to promptly recognize the occurrence of a coronary artery perforation. Employing an angiographic categorization system proves to be of significant value in guiding the treatment strategy. Swiftly addressing the perforation and attending to any hemodynamic concerns play a pivotal role in handling these instances. An interventional cardiologist should anticipate the potential occurrence of arterial perforation during PCI procedures. This preparation allows us to develop a handling strategy in the event of perforation. Nonetheless, additional clinical investigations with long-term clinical and angiographic follow-up are imperative to formulate general recommendations for the management of coronary artery perforations during percutaneous coronary intervention.

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