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A Unique Complication of the Retrograde Approach in Angioplasty for Chronic Total Occlusion of the Coronary Artery

Jyunya Matsumi,* MD, Koichi Adachi, MD, and Shigeru Saito, MD, FACC, FSCAI

The retrograde approach for chronic total occlusion of coronary arteries is a new treatment strategy, although its attendant complications have not yet been fully appreciated. We report a case of isolated left ventricular cardiac tamponade caused by guidewire-induced perforation of the septal branch during the retrograde approach, which was subsequently diagnosed by computed tomography (CT) and which required surgical drainage. Guidewire-induced perforation of the septal branch was successfully treated by autologous subcutaneous tissue embolization of the perforated coronary artery. This is the first case of its kind to date.

Key words: collaterals; total occlusions; percutaneous coronary intervention

INTRODUCTION

The retrograde approach is one of the most promising techniques for percutaneous treatment of chronic totally occluded coronary arteries (CTO) [1,2]. A septal branch is the main route used in the retrograde approach [3]. Because this technique still in its infancy, its complications have not yet been fully appreciated.

We report a case complicated by an isolated left ventricular tamponade after coronary artery perforation. This was caused by the tip of the retrograde guidewire through the septal channel during the retrograde approach for a CTO lesion in the left anterior descending coronary artery (LAD), and it was successfully sealed by the selective injection of autologous subcutaneous tissue. The isolated left ventricular tamponade was diagnosed by computed tomography (CT), which was superior to that of transthoracic echocardiography. Although this rare type of cardiac tamponade occurred during the percutaneous coronary intervention of the retrograde approach, it might also present in patients during the antegrade approach with a history of cardiac surgery, making this a potentially far more common complication, as percutaneous coronary intervention becomes more commonplace in the future.

CASE REPORT

A 64-year-old male was transferred to our institution with an acute inferior myocardial infarction in May 2007. Emergency coronary angiography was performed and showed total occlusions in both the proximal right coronary artery (RCA) and the LAD, respectively. Successful recanalization of the RCA resulting in TIMI grade 3 flow was achieved by thrombectomy and primary stent implantation with a 4.0 mm × 24 mm Driver® stent (Medtronic, USA) following the insertion of an intra aorta balloon pump (IABP). Follow-up coronary angiography showed a CTO lesion in the LAD at its ostium, which was well supplied through rich collaterals via septal branches from the RCA (Fig. 1A,B).

Percutaneous coronary intervention (PCI) of the CTO lesion in the LAD was subsequently undertaken 5 months later. After the administration of 10,000 units of intravenous heparin, two 7-French guiding catheters (SAL1.0-SH 90-CM and EBU3.5 100-CM, Launcher®) were engaged in the RCA and the LAD, respectively

Division of Cardiology and Catheterization Laboratories, Heart Center of ShonanKamakura General Hospital, Yamazaki, Kamakura City, Japan

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*Correspondence to: Division of Cardiology and Catheterization Laboratories, Heart Center of ShonanKamakura General Hospital, 1202-1 Yamazaki, Kamakura City, Japan 247-8533.
E-mail: mjunya@h6.dion.ne.jp

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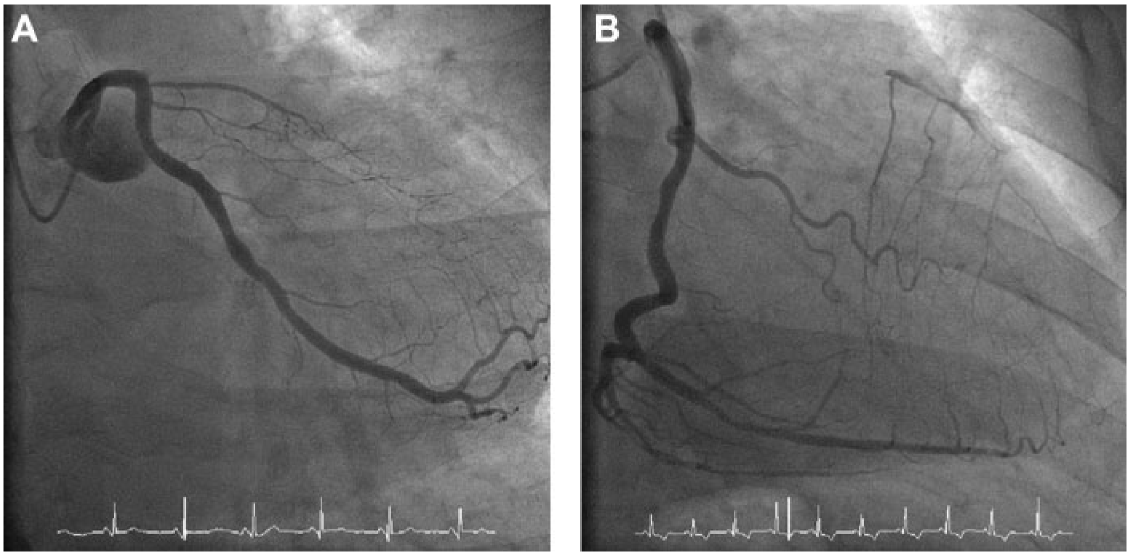

Fig. 1. **(A) Diagnostic left coronary angiography in straight caudal view showing the chronic total occlusion at the ostium of the LAD. (B) Diagnostic right coronary artery angiography in right anterior oblique (RAO) caudal view showing good collaterals from the RCA to the LAD via septal channels.**

via the femoral arteries. The retrograde approach was chosen in preference to the antegrade approach because the CTO lesion in the LAD was visualized as an abrupt occlusion at its ostium, making the latter technique too difficult to achieve successful recanalization. The retrograde approach was first attempted through the 2nd septal branch by using the combination of a Fielder X-treme® plastic-jacket hydrophilic guidewire (Asahi Intecc, Japan) with a Finecross® microcatheter (Terumo, Japan) (Fig. 2A). After the X-treme guidewire reached the LAD distal to the CTO lesion, in order to cross the CTO lesion retrogradely, the guidewire was exchanged to a Miracle 3® guidewire (Asahi Intecc). However, the angle between the septal branch and the LAD was so acute that the attempts to introduce the Miracle 3 guidewire into latter artery were unsuccessful and resulted in the perforation of the septal artery near its junction with the LAD. Right coronary angiography revealed extravasation of the contrast dye into the myocardium, which was classified as an Ellis type II perforation [4] (Fig. 2B). Because the patient was asymptomatic and with no electrocardiographic changes or hemodynamic instability, the procedure was continued without further treatment for the coronary artery perforation. The retrograde approach was next attempted via the 1st septal branch, again by using the combination of the X-treme guidewire and the Finecross microcatheter. This was performed immediately after the right coronary angiography without additional guidewire manipulation in the 2nd septal branch (Fig. 2C). After the guidewire reached the LAD distal to the CTO lesion, it was exchanged to a Conquest-Pro® guidewire (Asahi Intecc) in order to penetrate the lesion retrogradely. Although it passed through the CTO lesion retrogradely (Fig. 2D), neither a 1.3 mm $\times$ 10 mm monorail balloon catheter (Lacrosse®, Goodman, Japan) nor a 1.25 mm $\times$ 10 mm over-the-wire balloon catheter (Ryujin®, Terumo) could be advanced. While leaving the retrograde guidewire in position as a landmark, an antegrade approach was commenced with the combination of a Conquest-pro 12g guidewire and a Finecross microcatheter, respectively. The antegrade guidewire passed through the CTO lesion along the retrograde guidewire (Fig. 2E), and the lesion was successfully dilated by a 3.0 mm $\times$ 15 mm balloon (Europa®, MEDISPES, Switzerland). At the time of the balloon inflation, the patient developed hypotension (60 mm Hg systolic), and a tachycardia of 120 beats per minute. Repeated right coronary angiography revealed extravasation of contrast dye into the pericardial space, which was classified as an Ellis type III perforation [4]. An immediate portable echocardiographic examination revealed what was considered to be a small amount of pericardial effusion at the posterior and lateral sides of the left ventricle. Pericardiocentesis was attempted, but fluid could not be aspirated. In view that the perforation had originally occurred in the LAD, hemostasis was first attempted by the inflation of a 3.0 mm balloon in that artery. However, when angiography of the right coronary artery was performed, during inflation of the balloon in the LAD, it revealed contrast jet extravasation from the 2nd septal branch (Fig. 2F). To achieve hemostasis, a Finecross microcatheter was introduced with a Fielder-FC® guidewire (Asahi Intecc) near the perforation site of the 2nd septal branch via the RCA. Subcutaneous adipose tissue was then extracted from the patient's groin at the site of the femoral sheath insertion. While the tip of the microcatheter was positioned proximal to the perforation of the 2nd septal branch, several fragments of the subcutaneous tissue were pushed by the retrograde guidewire, following injection with saline, through the microcatheter (Fig. 2G). Following this procedure, the right coronary angiogram showed complete hemostasis of the 2nd septal branch (Fig. 2H). Because the patient remained hypotensive, a continuous infusion of catecholamines with both dopamine and dobutamine were commenced in addition to intra-aorta balloon pumping (IABP). Following these treatments, the patient's blood pressure only improved to 80 mm Hg systolic. A 3.0 mm $\times$ 33 mm Cypher® stent (Cordis, USA) was placed at the ostium of the LAD and a follow-up left coronary angiogram showed a good final result with TIMI grade 3 flow (Fig. 2I).

The pericardial effusion detected at the posterior and lateral sides of the left ventricle by transthoracic echocardiography appeared too small to cause cardiac tamponade and the patient had none of the typical physical signs indicating this condition such as pulsus paradoxus or internal jugular vein distension. The patient's systolic blood pressure worsened to 60 mm Hg, while in the Intensive Care Unit despite the continued infusion of catecholamines and volume expander with blood transfusions under IABP support. Repeated transthoracic echocardiography 4 hr after the PCI procedure showed no change of the pericardial effusion compared with that performed earlier (Fig. 3A,B). However, CT revealed a large amount of pericardial effusion localizing around the lateral sides of the left ventricle (Fig. 4). Coronary angiography was repeated, and complete hemostasis of the 2nd septal branch was reconfirmed. Right heart catheterization was performed by using a Swan-Ganz catheter, which showed identical low-mean right atrial and pulmonary capillary wedge pressures (4 mm Hg) respectively, and a low-cardiac output (2.05 L/min/m^2). Because percutaneous drainage of the pericardial effusion had been previously unsuccessful, surgical drainage through a small incision in the subxiphoid area was undertaken, which recovered 350 ml of bloody pericardial fluid. The patient's blood pressure immediately increased following this procedure, and both the catecholamine infusion and IABP support were subsequently stopped. No cardiac enzyme elevation was observed. The patient was discharged from the hospital 12 days post-PCI without any long-term sequelae.

DISCUSSION

A previous study have shown the importance of revascularization of CTO lesions with improvement in anginal symptoms, exercise capacity, left ventricular function, and long-term survival [5]. In spite of improvements in guidewires, devices, and operators' techniques in the last 20 years, the success rate of PCI for CTO lesions is still suboptimal [5].

In this regard, the retrograde approach is considered to be one of the most promising techniques for PCI of CTO lesions [1,2].

The indication for revascularization of the CTO lesion in this patient was considered to be appropriate, because this patient had Canadian Cardiovascular Society class 2 angina, and he had previously rejected coronary artery bypass graft surgery.

Because a continuous septal connection is found frequently in CTO cases, the use of the septal collateral channel increases the clinical application of the retrograde approach for such CTO lesions [3,6].

A previous study showed a rate of the in-hospital complication for recanalization of CTO lesions was relatively low (death: 1.3%, Q-wave myocardial infarction: 0.5%) [5]. From this report, if the PCI of CTO lesions in the retrograde approach was undertaken by a highly experienced operator, it was also considered to be relatively safe, in which there was no complication with death or myocardial infarction during the retrograde approach [3].

Although coronary artery perforation is one of the most serious complications during PCI for CTO lesions in the conventional antegrade approach, it has yet to be described in the literature during the retrograde approach.

Coronary artery perforation is classified into four types [4]: type-I, extraluminal crater without extravasation; type-II, pericardial or myocardial blush without contrast jet extravasation; type-III, extravasation through frank (>1 mm) perforation; type-CS (cavity spilling), perforation into an anatomy cavity chamber, coronary sinus, etc.

Coronary artery perforation has a high mortality, especially if it is accompanied by cardiac tamponade resulting from an Ellis type-III perforation [4,7]. Thirty-six percent of coronary artery perforations are caused by the manipulation of guidewires [8]. Currently, stiff and hydrophilic guidewires are frequently used in CTO cases, and these guidewires are more likely to cause coronary artery perforation [9]. More-

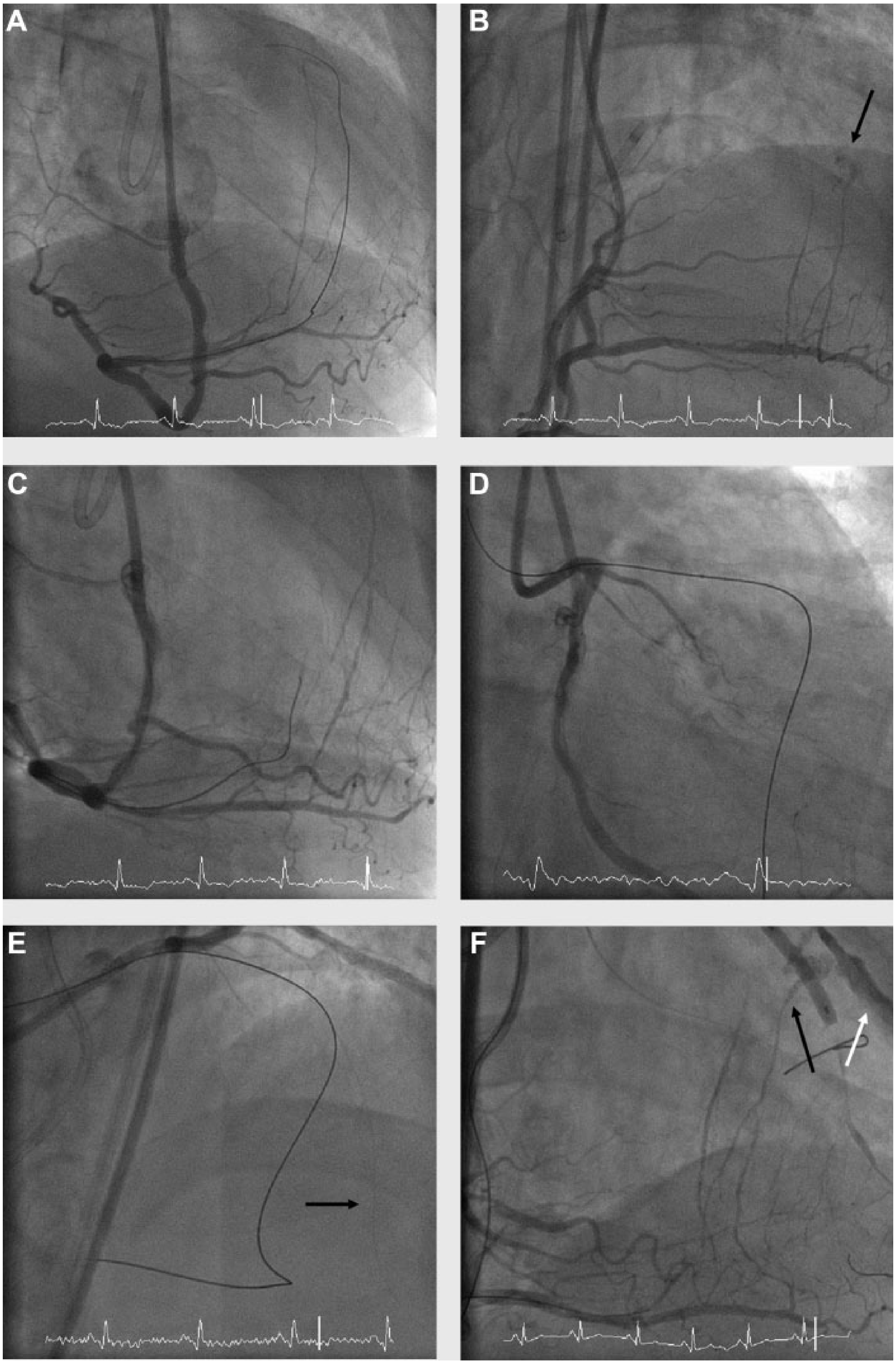

Figure 2.

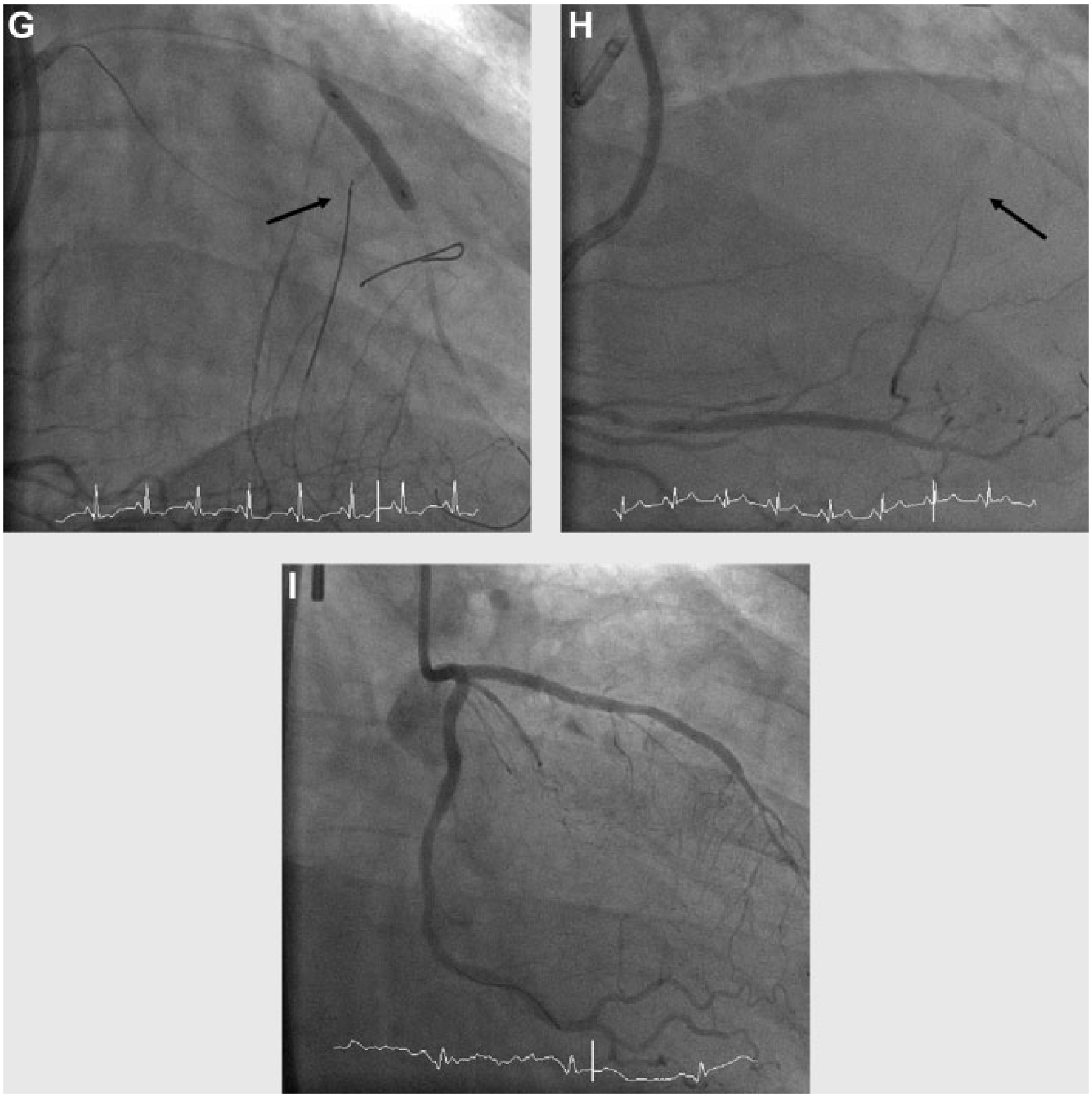

Fig. 2. (Continued)

over, coronary artery perforation during PCI occurs more frequently in such CTO lesions, which have been previously treated in the conventional antegrade approach, rather than with non-CTO lesions. Subcutaneous tissue embolization used to achieve hemostasis for coronary artery perforation in this retrograde approach might also be useful for such occurrences in the antegrade approach. Distal coronary artery perfora-

Fig. 2. (A) (RAO cranial view) The retrograde approach was employed via the 2nd septal branch. (B) After the removal of the retrograde system from the 2nd septal branch, right coronary angiography showed the extravasation of contrast dye within the myocardium (black arrow). (C) The retrograde approach was attempted via the 1st septal branch. (D) The retrograde guidewire passed through the occluded lesion at the ostium of the LAD to the ascending aorta via the 1st septal branch. (E) The antegrade guidewire passed through the occluded lesion distal to the LAD (black arrow). (F) Although a balloon was dilated in the LAD, right coronary angiography revealed the extravasation of contrast dye from the 2nd septal branch (black arrow) to the pericardial space (white arrow). (G) Subcutaneous tissue was selectively delivered at the perforated portion in the 2nd septal branch by pushing the guidewire through a microcatheter via the retrograde route (black arrow). (H) Successful hemostasis by embolization of subcutaneous tissue in the 2nd branch (black arrow) was confirmed by right coronary angiography. (I): After a sirolimus-eluting stent implantation, left coronary angiography showed a good final result with TIMI 3 flow.

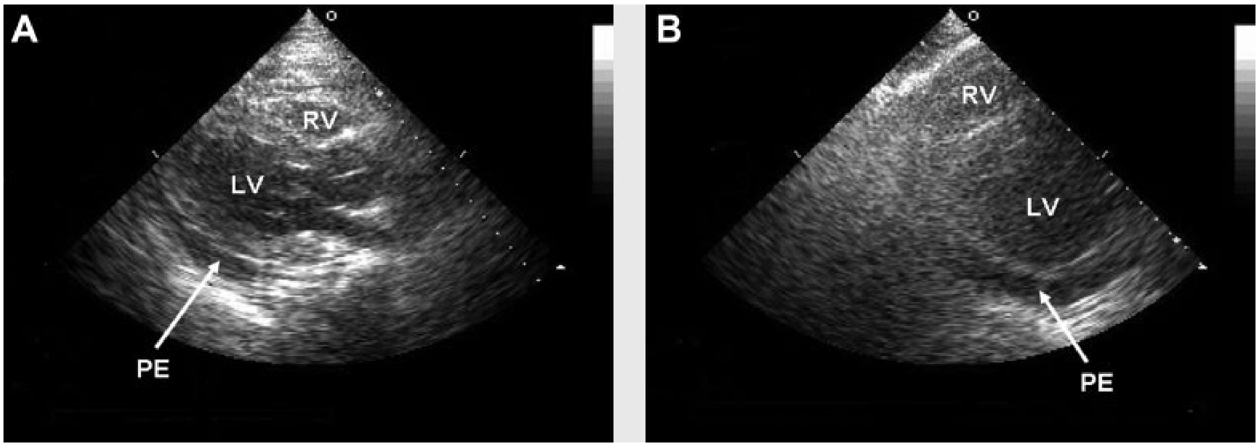

Fig. 3. **(A) Echocardiography from long-axial view showed a small pericardial effusion in the posterior of left ventricle. PE, pericardial effusion; RV, right ventricle; LV, left ventricle. (B) Echocardiography from subxiphoid view show a small pericardial effusion in the lateral sides of left ventricle.**

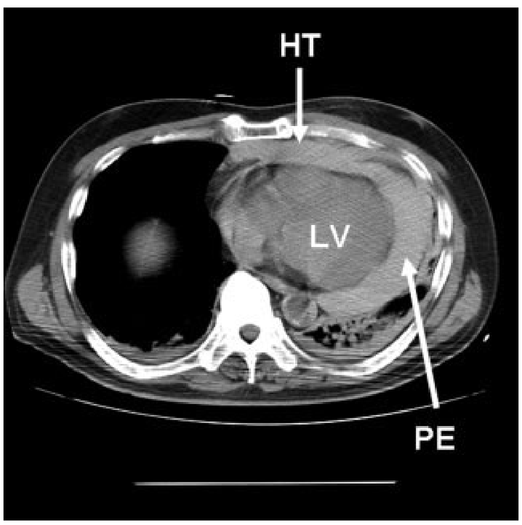

Fig. 4. **Plane computed tomography clearly showed a large amount of pericardial effusion around the left ventricle with a small hematoma abut on the epicardium caused by pericardiocentesis. HT, hematoma abut on epicardium caused by pericardiocentesis; PE, pericardial effusion; LV, left ventricle.**

tion during PCI of the antegrade approach has been treated by this procedure in a previous report [10]. The advantages of using subcutaneous tissue as an embolization material are the ability to use at any time, short preparation time, low cost, and no requirement to reverse heparin. Moreover, this procedure can be performed through a microcatheter, which is used for navigation of the retrograde guidewire to the collateral channel. There have been many other treatment strategies proposed to achieve hemostasis after coronary artery perforation, which include reversal of heparin, prolonged inflation of the PCI balloon [11], local injections of polyvinyl alcohol [12], Gelfoam [13], and thrombin [14].

As the subcutaneous embolization technique was employed in this case, the heparin was not discontinued. However, in retrospect, the Authors consider that the heparin should have been discontinued because this treatment may have led to the progression of an Ellis type II to type III perforation.

There have been several reports about guidewire-induced septal branch perforation through the retrograde approach, which did not require further interventional treatment [2,15]. However, the guidewire-induced septal branch perforation in this case resulted in cardiac tamponade, and both hemostasis by the embolization of the septal branch and the surgical drainage were required. The vascular anatomy observed in this case (the angle between the 2nd septal branch and the LAD was acute) was considered to affect the 2nd septal branch perforation. Careful manipulation of the guidewire is essential to prevent this complication.

In general, cardiac tamponade is characterized by right ventricular collapse, elevated and equal right atrial, pulmonary capillary wedge and intrapericardial pressures, and decreased cardiac output with hypotension [16,17]. The disturbance in the right ventricular filling with elevated right atrial pressure causes classical signs of cardiac tamponade, such as pulsus paradoxus and internal jugular vein distension [16].

In this case, it was difficult to establish the diagnosis of cardiac tamponade because the patient exhibited no clinical signs of this problem, and the echocardiogram revealed only a small effusion and no right ventricular collapse. Moreover, both mean right atrial and pulmonary capillary wedge pressures were as low as 4 mm Hg. As a result, these findings required the differential diagnosis of hypovolemic shock to be considered due to blood loss. The patient was hemodynamically stable before the procedure with no signs of hypovolemia on physical examination and, the biochemical data was normal and hemoglobin was 15.3 g/dL. Moreover, the patient's systolic blood pressures worsened despite continued infusion of volume expander with blood transfusions before performing surgical drainage. In this case, because the pericardial effusion mainly localized around the posterior and lateral sides of the left ventricle rather than the anterior sides of the right ventricle, these unusual hemodynamic features were observed. Although the physical evaluation, echocardiography findings, and cardiac pressures were atypical for cardiac tamponade, it was nevertheless still considered to be the likely cause of cardiogenic shock. The patient's blood pressure recovered to normal after surgical drainage without requirement of further supportive therapy thereby giving further weight to the diagnosis.

Although in most cases, transthoracic echocardiography is useful in diagnosing cardiac tamponade [17,18], there is a potential risk for underestimating pericardial effusions by this techniques and CT might be more helpful in similar cases to this [16,19]. This fact should be borne in mind, if an unknown cause of shock develops during or after PCI with only a small amount of pericardial effusion visualized during transthoracic echocardiography, because delay in the diagnosis of cardiac tamponade is potentially lethal. Early establishment of the diagnosis and prompt treatment is required when cardiac tamponade develops. Although transesophageal echocardiography (TEE) was not performed in this case, TEE might also have been useful in visualizing the pericardial effusions.

There have been several articles reporting localized pericardial effusion presenting with isolated left ventricular tamponade after cardiac surgery [18,20]. To our knowledge, this is the first report describing localized pericardial effusion leading to cardiac tamponade caused by coronary artery perforation during PCI without any history of previous cardiac surgery. There are several reasons considered to be the cause for this type of isolated cardiac tamponade. Pericardial adherences, despite a lack of history of surgery or pericardial disease are one of the likely reasons. Another likely reason is the bleeding after coronary artery perforation into the subpericardial space, that led to localized pericardial effusion. This type of isolated cardiac tamponade might be unique for the retrograde approach when using the septal branch as a retrograde route. It might also develop in patients with a history of cardiac surgery, complicated by coronary artery perforation during PCI of the antegrade approach.

This case is the first report with selective injection of autologous subcutaneous tissue to achieve hemostasis after guidewire-induced septal artery perforation during the retrograde approach for a CTO lesion.

In conclusion, this case demonstrates that guidewire-induced septal branch perforation through the retrograde approach can cause isolated left ventricular cardiac tamponade, which may present with signs of shock without the classical signs of tamponade and only modest signs of pericardial effusion fluid accumulation using transthoracic echocardiographic studies. The retrograde approach is the most promising techniques for PCI of CTO lesions, and the septal collateral channel is most frequently used as a retrograde route. In this regard, this complication should be borne in mind in the future when the septal channel is used as a retrograde route.

Although this complication might be unique and rare for PCI of the retrograde approach, it may also potentially occur during PCI of the antegrade approach in patients with a history of cardiac surgery when coronary artery perforation occurs.

Delay in the diagnosis of cardiac tamponade is potentially lethal. This case is a clear warning message to avoid sole reliance on transthoracic echocardiographic studies in diagnosing cardiac tamponade and to consider obtaining more detailed information using CT examination or TEE.

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