14. Managing Acute Complications
i) Coronary Perforation

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1)　Definition

Coronary perforation is defined by the persistent extravascular loss and accumulation of contrast medium through the vessel wall. Though the frequency of coronary perforation is not high, it is a serious complication when it occurs in the setting of percutaneous coronary intervention (PCI). Reported to occur in about 0.1% of cases in balloon angioplasty, the incidence of angiographic perforation is thought to be 0.5%~ 3.0% in procedures involving the so-called newer devices.

2)　Diagnosis

Coronary perforation can be easily diagnosed by coronary angiography and echocardiography, and is usually accompanied by new episodes of angina pectoris, changes in hemodynamic conditions and changes on ECG. The most difficult type of diagnosis is when there is extramural blood tumor pressing on the blood vessel wall. This condition can only be detected indirectly from coronary angiography.

Some patients suffer cardiac tampanade from several hours to several days after angioplasty. If serious, the patient should be kept under careful observation in the intensive care unit. Repeat angiography is a good way to diagnose slow-type perforations, but it is vital to monitor heart rate, blood pressure, right atrial pressure, pulmonary pressure and cardiac output. If right atrial pressure rises with no accompanying change or decrease in pulmonary pressure, ECG should be performed to assess any increase in fluid at the pericardium. In addition, if a decrease in blood pressure is detected after angioplasty, slow-type perforation must be suspected, and ECG performed immediately. If a 5~7mm echo free space is detected on ECG, then pericardial puncture is the best option to drain the fluid. This kind of iatrogenic complication is most likely to have been caused by a balloon, one of the new devices or a guidewire.

3)　Classification

We classify perforations into two broads types:

Type 1: Discrete or localized extravascular flow oozing into the myocardium or epicardium. This perforation is usually caused by guidewires, but balloons and atherectomy devices may also be to blame.

Type 2: Persistent extravascular flow evidenced by loss of contrast medium through a lesion. Balloons and atherectomy devices are usually responsible for this type of perforation.

4) Risk Factors

Perforation by guidewire is especially prevalent when treating CTO lesions. Aggressive strategies such as those using a guidewire with hard tip entail a relatively higher risk of perforation. Perforation during PTCA is most likely to occur when advancing the guidewire or balloon, or when the balloon is dilated, or ruptures. Just as dilating a vessel with a balloon can cause dissection, over-dilatation and over-stretch can cause a dissection all the way into the adventitia which leads to perforation. The risk of dissection and perforation is even further increased in the event of balloon rupture, especially pinhole rupture because of the resulting high-pressure jet this phenomenon releases. The newer devices such as DCA, Rotablator and stent may be effective for obtaining larger lumen areas, but they are also associated with higher rates of coronary. A balloon/artery ratio >1.3:1 is thought to be especially risky during stenting. Always bear in mind, that irrespective of what device you are using, the danger of perforation is increased in complex cases such as CTOs, bifurcations, tortuous lesions, and those on proximal bends and calcified lesions.

5) Preventative Measures

The risk of perforation exists the moment the guidewire is inserted and remains throughout the interventional procedure intervention until the last wire has been removed.

a) Guidewires

For all PCI, the guidewire tip should cross the stenosis smoothly and maintain a good torque response. If the guidewire gets twisted, its movement seems restricted, or you feel resistance at the tip, the chances are that guidewire has slipped below the intima. If that happens, pull it out and start again. if you have selected one of the stiffer-tipped guidewires to treat severe tortuosity or a very occluded lesion, expect a comparable increase in the risk of perforation. Maintain guiding catheter back-up, grade up in stages to the stiffest wires, and go back to a soft-tip as soon the situation permits it. This is the best way to prevent perforation. Always remember to pay minute attention to the wire as long as it is in the lumen. This is crucial for checking that the tip is moving freely and for confirm the location of the wire by angiography, which is another key part of the process. Never dilate a balloon until you are sure your guidewire is where it should be. For CTO lesions, guidewire-induced perforations rarely lead to cardiac tamponade. Another tip is that when exchanging balloons, you should avoid placing hydrophilic or stiff wires very distally into the vasculature. If you have to, keep a very close eye out for slow-type cardiac tamponade.

b) Balloons

Balloon-induced perforation is largely attributable to one of two main causes, balloon rupture and over-dilation. Balloon rupture tends to happen most frequently in calcified lesions, so you need to be aware of the balloon's burst pressure and what material the balloon is made of. When you dilate, dilate at the minimum pressure required to obtain the lumen you need at the lesion, and give some thought to using a high-pressure balloon minimize trauma to hard lesion and calcified lesions. Balloon rupture does not usually affect the lesion, because of the contrast medium already in the coronary. If however, the balloon is touching the vessel, and especially if proximal calcification causes pinhole rupture, the resultant high-pressure release can make a small hole and leading to dissection and extravascular flow of the

contrast medium and blood. Over-dilation of balloons similarly increases the danger of coronary perforation. Particular care must be taken in high-risk lesion types, such as diffuse angulated, bifurcation or CTO lesions, to raise balloon size and inflation pressure in gradual stages, starting with a undersized balloon and working up to a balloon/artery ratio of 1:1.

c) Other Devices ~ DCA and rotablation

Considering the dangers associated with perforation and the efficacy of stents, DCA is not recommended as a strategy for treating dissection. Perforation caused by stents may be avoided by careful attention to balloon size and stent placement. Note also, that a rotablator burr/artery ratio of >0.8 is highly correlated with perforation. In high-risk lesions (angulated lesions, bifurcations etc) treatment should begin with a small burr and not exceed a ratio of 0.5~0.6.

6) Managing Coronary Perforation

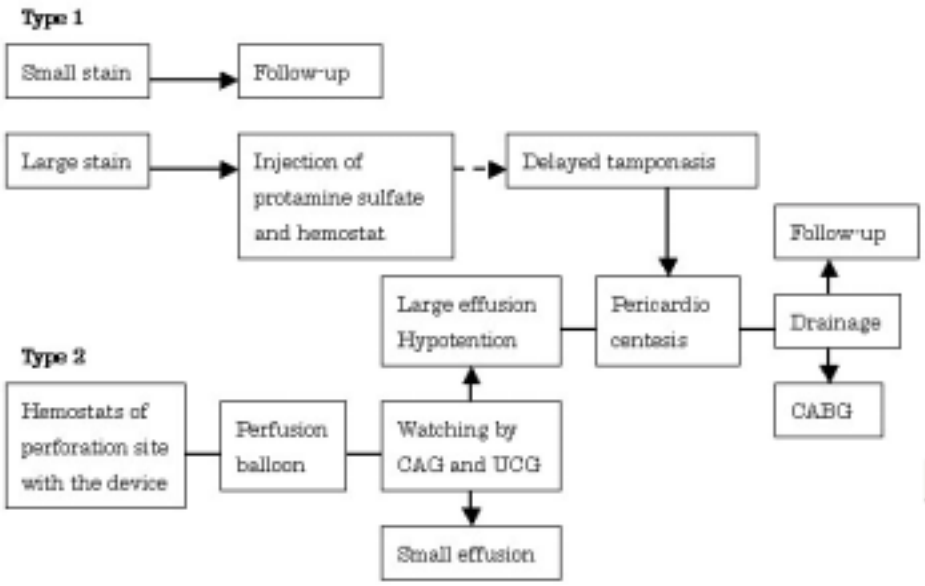
Generally speaking, with localized or guidewire-induced perforation, hemodynamic conditions will be stable, and treatment able to prevent any kind of deterioration. When the problem is caused by a balloon or an atherectomy device, though, emergency invasive treatment is required immediately to prevent hemodynamic breakdown. Irrespective of the causes, early management is important for plugging the perforation without resorting to surgery. Stabilizing the hemodynamic situation is also crucial.

a) Identify the perforation and effect hemostasis.

b) Stabilize the hemodynamics

<Figure 1>

Figure 1
Management for coronary perforation



7) Managing Type 1 Perforations

a) When small localized oozing or fluid-release is detected, monitor it carefully.

b) If the fluid-release is large, administer protamine to negate the effects of heparin.

c) In the event of slow-type cardiac tamponade, puncture the pericardium to relieve the pressure there. Use a pigtail catheter to drain off the fluid, and do repeat angiography to check the perforation. If the perforated site is clearly visible, dilate a balloon to achieve hemostasis. If the perforated site is not visible, the coagulation of the blood flowing via the pigtail catheter will be your guide for hemostasis.

<Figure 2>

Figure 2 Type 1 perforation

Figure 2-1 Pre-procedure

Figure 2-2 Balloon rupture caused by balloon dilation (Sierra 2.0 × 20 mm at 6atm)

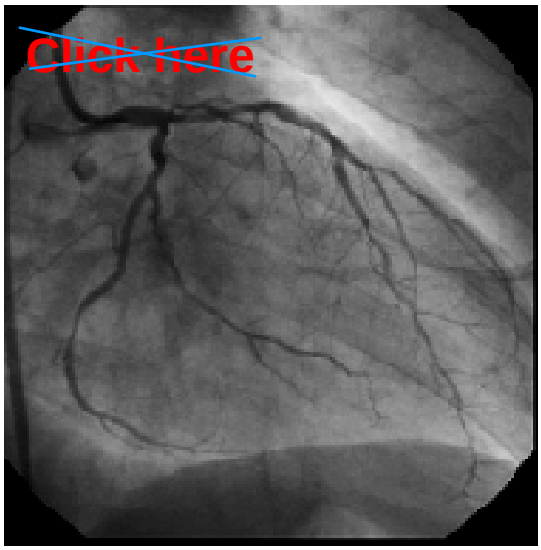


Figure 2-3 Type 1 perforation

Figure 2-4 Hemostasis performed post-procedurally after monitoring progress.

8) Managing Type 2 Perforations

a) Immediately put the balloon you are using (this is before pericardial-puncture, IABP or CPR) at the perforation site. Dilate the balloon to avoid further blood loss.

b) If ischemia develops, switch the balloon for a perfusion balloon.

c) If cardiac tamponade and low blood pressure ensue, make a puncture site in the pericardium and drain with a pigtail catheter.

d) Begin dilation of your perfusion balloon at the perforation site with the minimum pressure capable of ensuring hemostasis.

e) A pressure of 1-2atm is usually required, and gradually decrease to zero. A long inflation of 10~30 minutes or even more will be required, to allow a thrombus to form at the perforated site and plug the extravascular flow.

f) Do not give any additional heparin. For hemostasis, give protamine to neutralize the heparin you have already given, and administer a hemostasis pack (4 amps of Adona (carbazochrome sodium sulphate), 2 of Transamin (tranexamic acid), 3 of K2 (menatetrenone), and 1 of reptilase).

g) The most important point to remember when attempting hemostasis is that it is achieved not simply by the dilation of the perfusion balloon but by the decreasing inflation pressure over time, with intervals for the hemostatic agents to spread to the perforation site.

< Figure 3,4>

Figure 3 Type 2 perforation

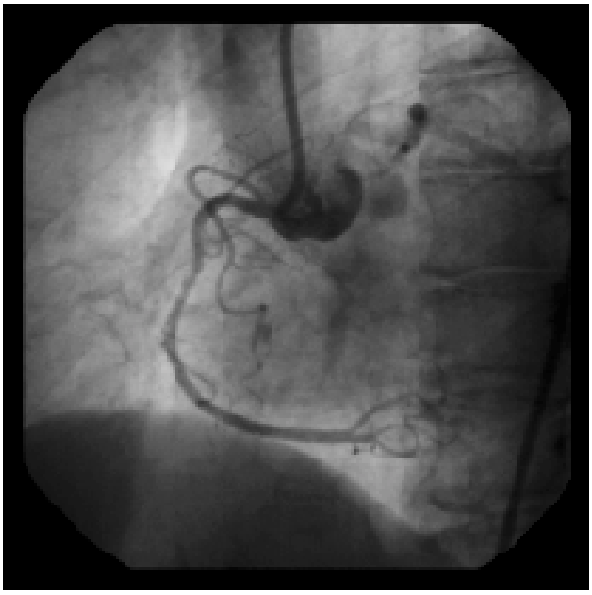


Figure 3-1 Pre-procedure

Figure 3-2 Cutting balloon dilatation (3.5 × 15 mm at 10atm)

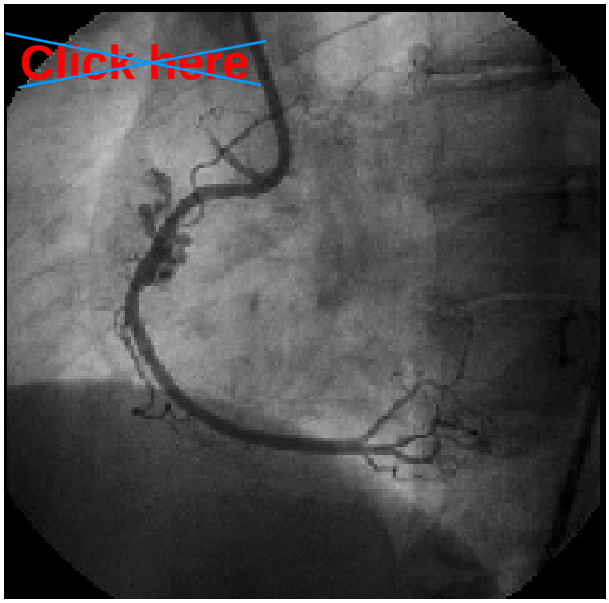


Figure 3-3 Type 2 perforation

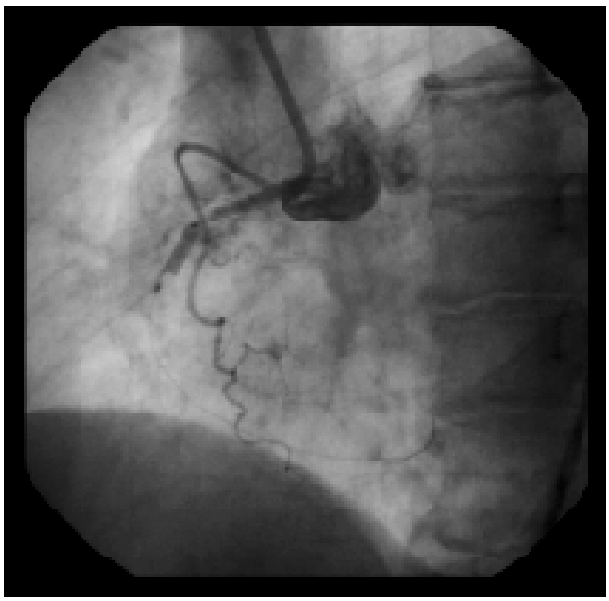


Figure 3-4 Hemostasis with a cutting balloon at a low pressure

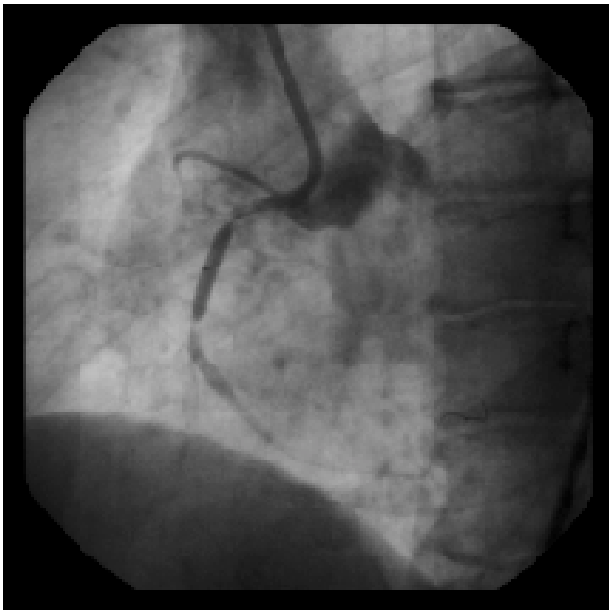


Figure 3-5 Hemostasis with a perfusion balloon (LifeStream 3.5 × 20 mm)

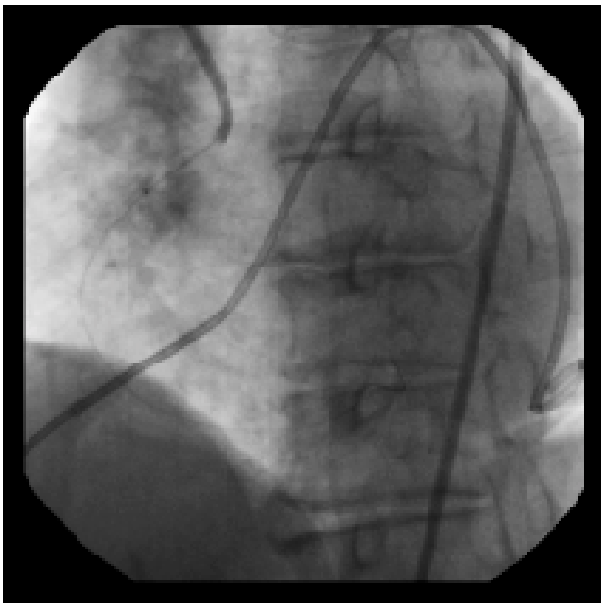


Figure 3-6 Drainage using a pigtail catheter

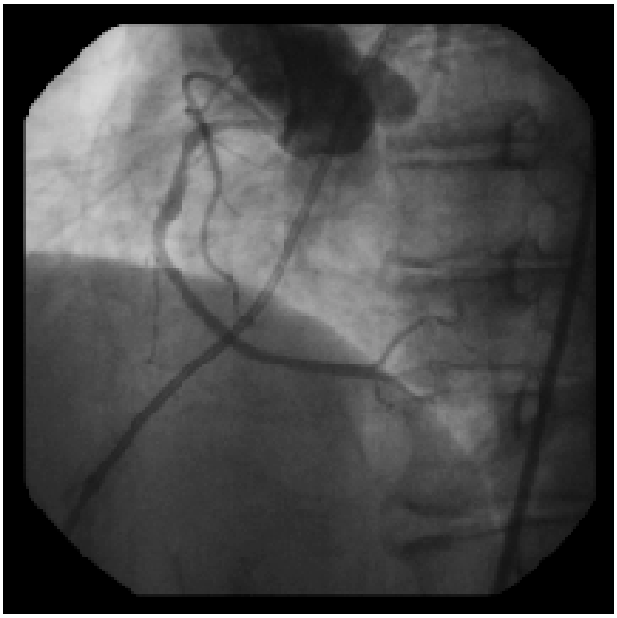


Figure 3-7 Post-procedure

Figure 4 Type 2 perforation in lesion on bent

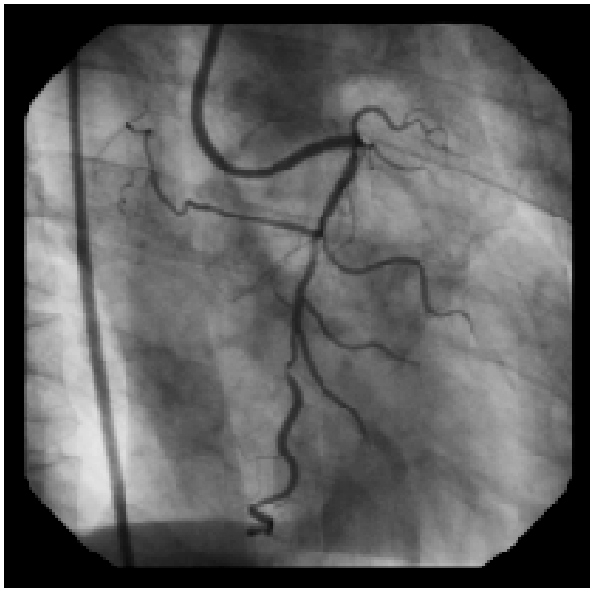


Figure 4-1 Lesion prior to procedure

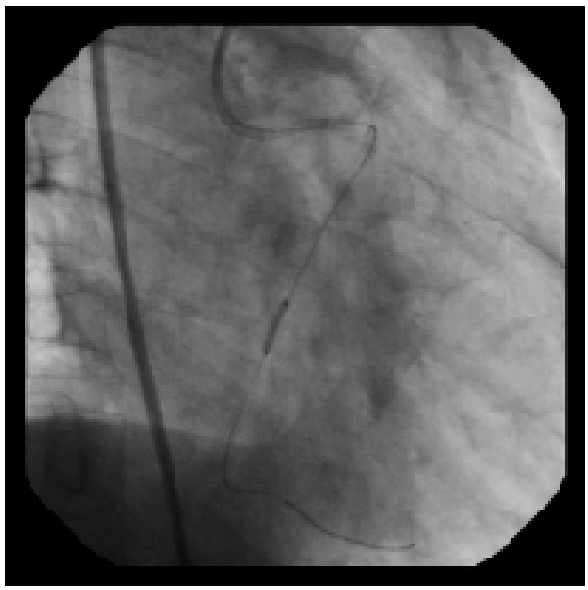


Figure 4-2 Cutting balloon dilatation (2.5 × 10 mm at 12atm)

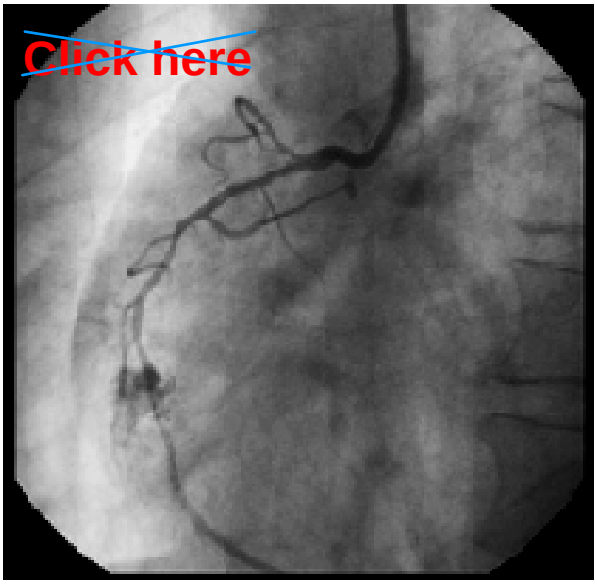


Figure 4-3 Type 2 perforation

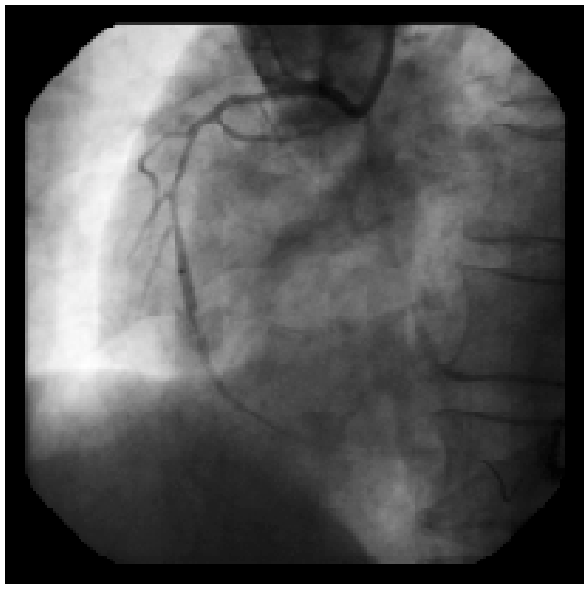


Figure 4-4 Hemostasis with a (LifeStream 2.5× 20mm) perfusion balloon, during which 5ml protamine and 2 hemostasis packs were given.

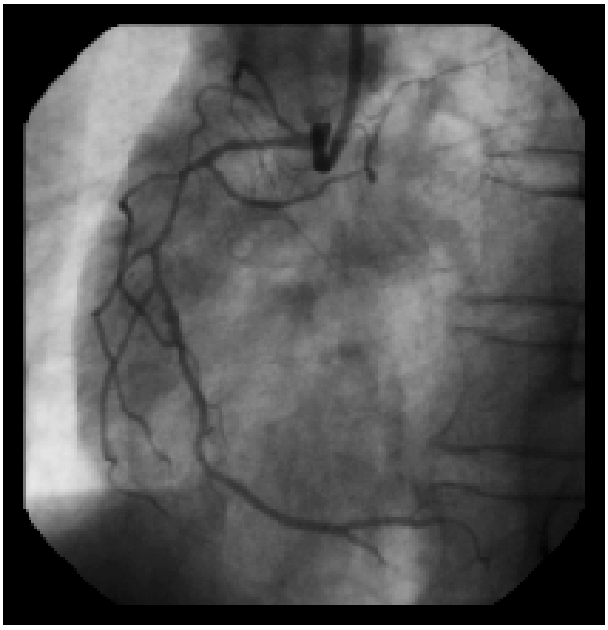


Figure 4-5 Post-procedure

9) Embolization

If the perforation persists, and for whatever reasons, such as it is too distal, or in a small vessel, or it is near a CTO, or there is poor myocardial viability, or surgery is not possible, coil embolization is one of your treatment options. For a distal perforation caused by a guidewire, besides dosing protamine, or dilating a balloon at and proximal to the perforation, there is also the possibility of injected gel foam strips onto the site through an infusion catheter.

< *Figure 5* >

Figure 5 Coil embolization

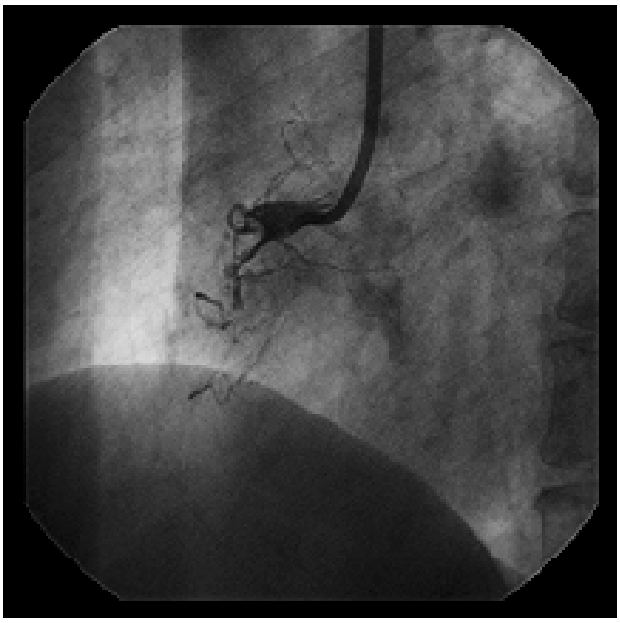


Figure 5-1 Pre-procedure
CTO lesion with high thrombus-burden.

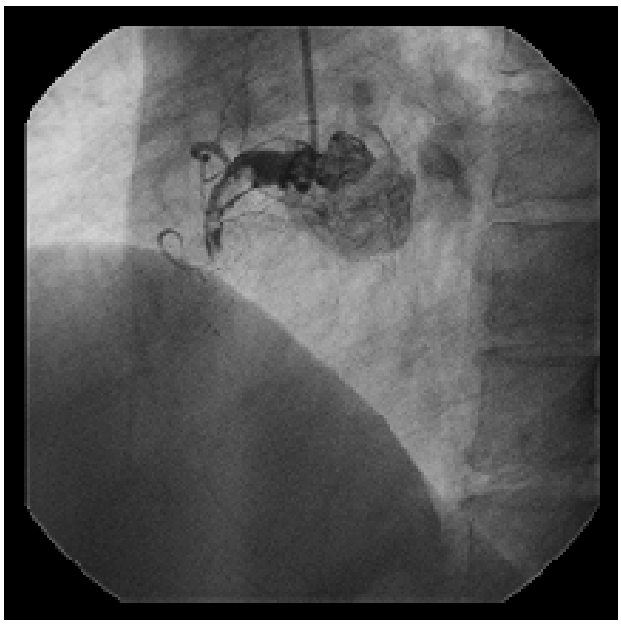


Figure 5-2 Following intravenous administration of 840,000U of urokinase

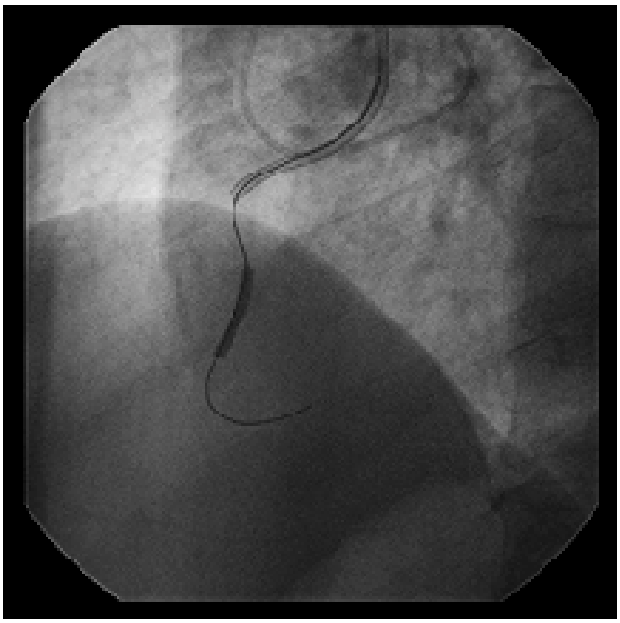


Figure 5-3
Balloon dilation (Renger 2.5 × 20 mm)

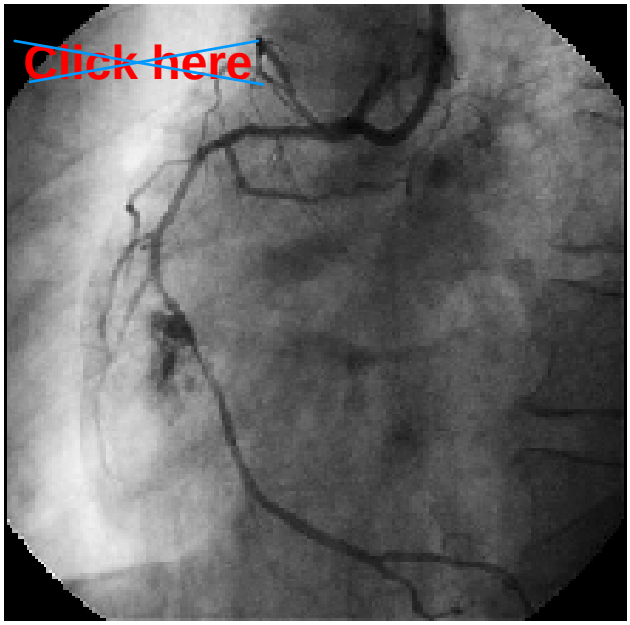


Figure 5-4 Type 2 perforation

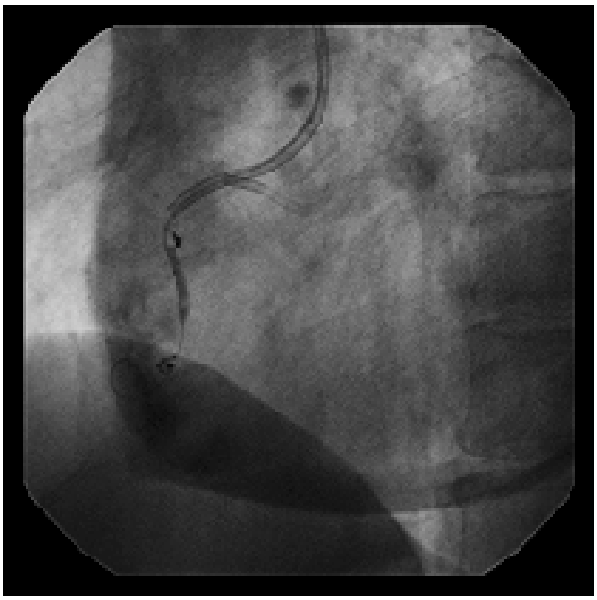


Figure 5-5　Coil embolization

Hemostasis was not effected despite dilatation of in-situ PTCA balloon and administration of hemostatic agents. Coil embolization (using 3 pieces of micro-coil) was performed.

Figure 5-6 Post-procedure

10)　Stents

If extravascular flow continues despite balloon dilatation, a covered or poly-tetra-fluorethylene (PTFE)-covered stent may be of use in effecting hemostasis. However, preparing these covered stents is technically difficult and the hemodynamic situation may not allow that much time. Some reports suggest that PTFE-covered stents may be an effective way to achieve hemostasis without resorting to emergency CABG. Early release of this product in Japan is anticipated..

11)　When to Resort to Surgery?

If a large perforation is causing serious ischemia or you cannot re-cross the guidewire, or if bleeding continues despite the above-mentioned strategies, emergency surgery is the only option. If the situation allows, this should be done with a perfusion balloon in place, and dilated at low pressure.< *Figure 6* >

Figure 6　Emergency surgery

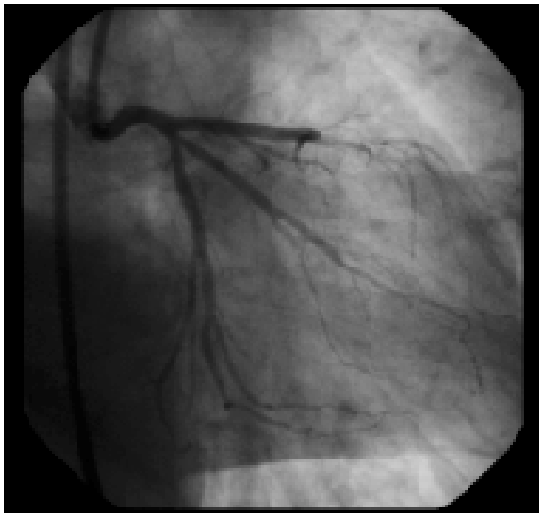


Figure 6-1 Pre-procedural CTO lesion

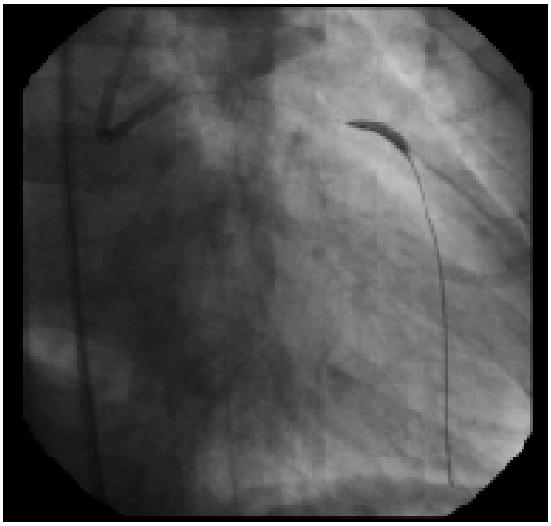


Figure 6-2

Balloon dilation (Inter Player 2.5 × 20 mm)

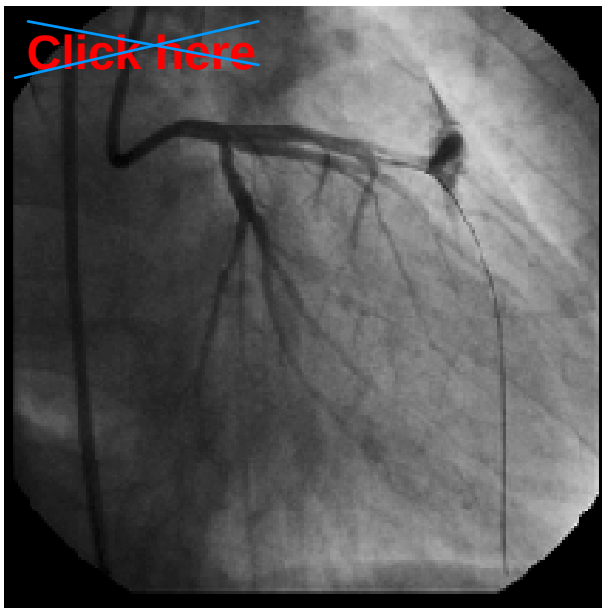


Figure 6-3 Type 2 perforation

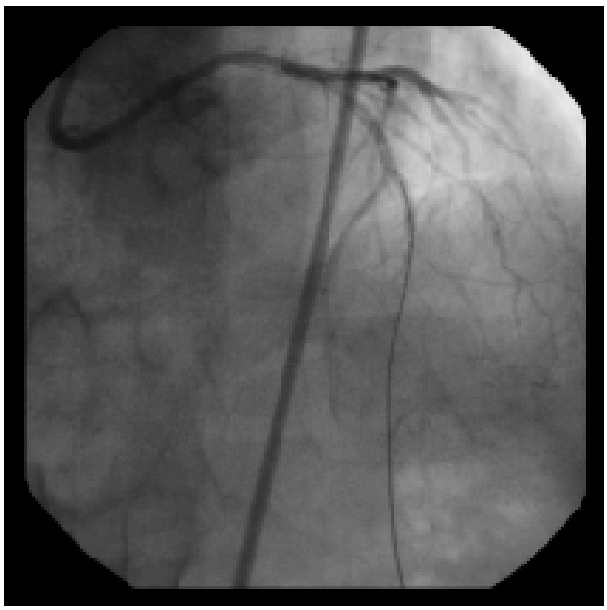


Figure 6-4

Hemostasis by dilatation of the in-situ balloon and hemostatic agents.

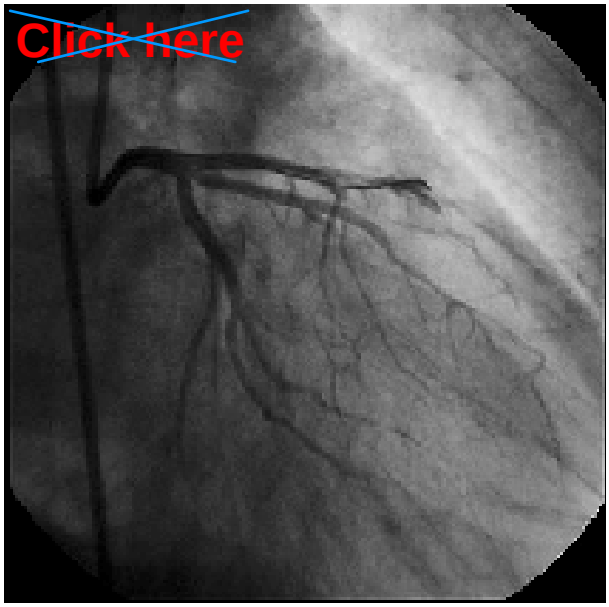


Figure 6-5 Post-procedure

Loss of guidewire position meant no effective hemostasis was feasible. Patient was sent for emergency surgery.

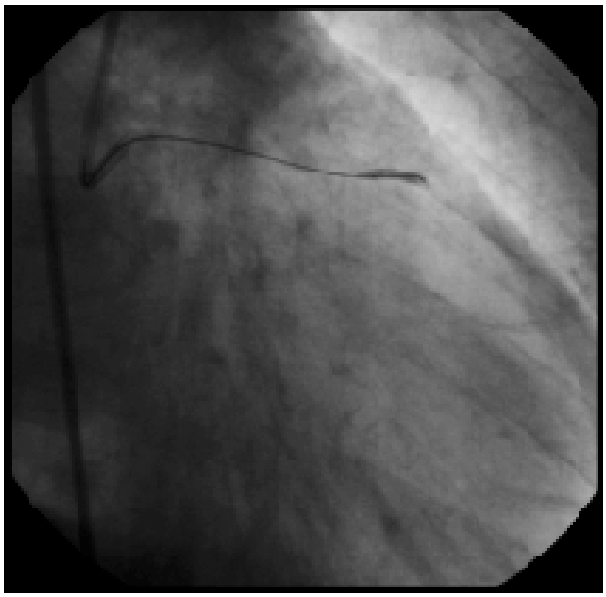


Figure 6-6

If possible, operate with a dilated perfusion balloon in place.