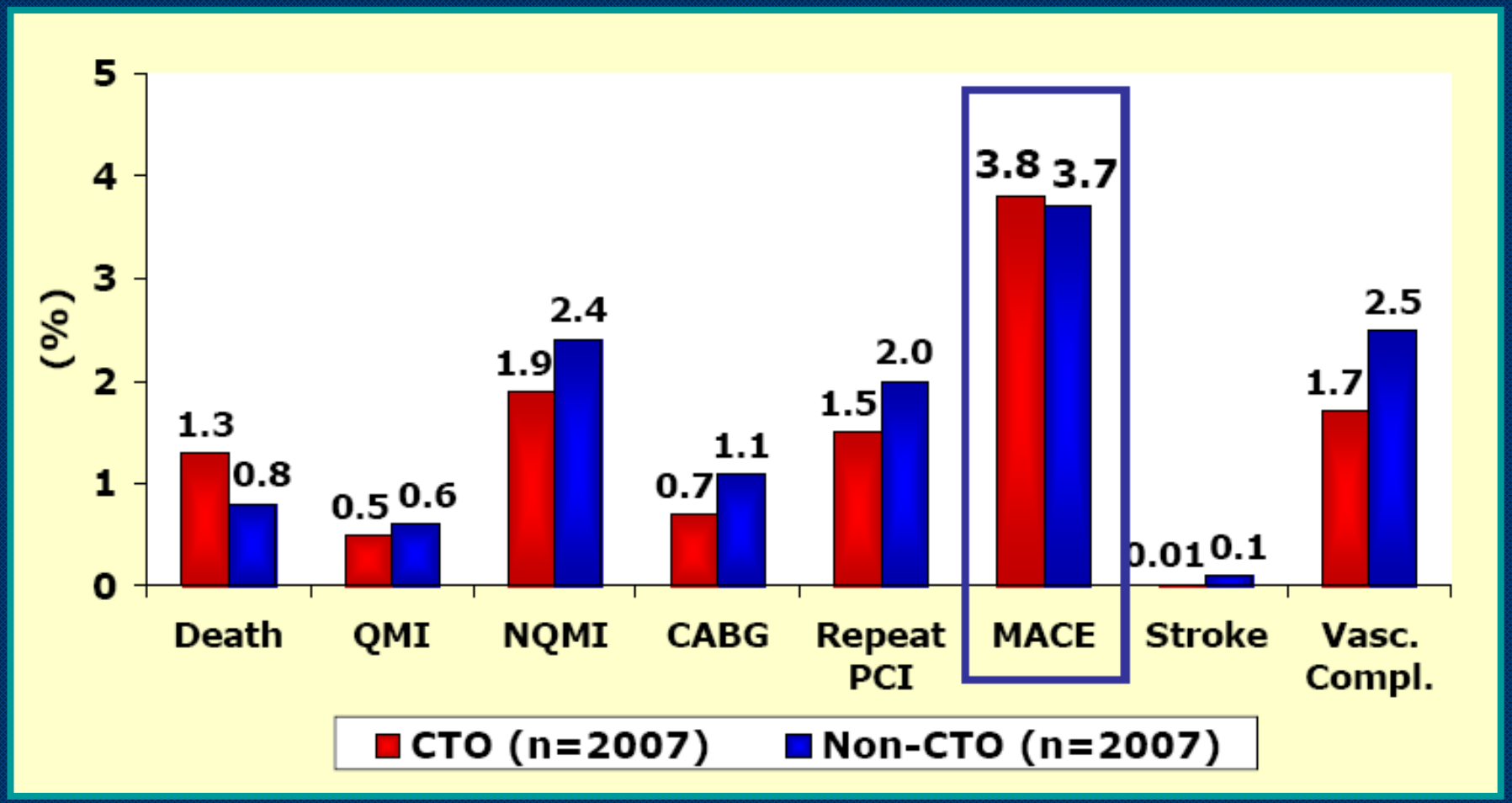
Dealing With Perforation in CTO Intervention

Teguh Santoso
University of Indonesia Medical School,
& the Medistra Hospital,
Jakarta, Indonesia

PCI of CTO Is *NOT* Completely Safe:

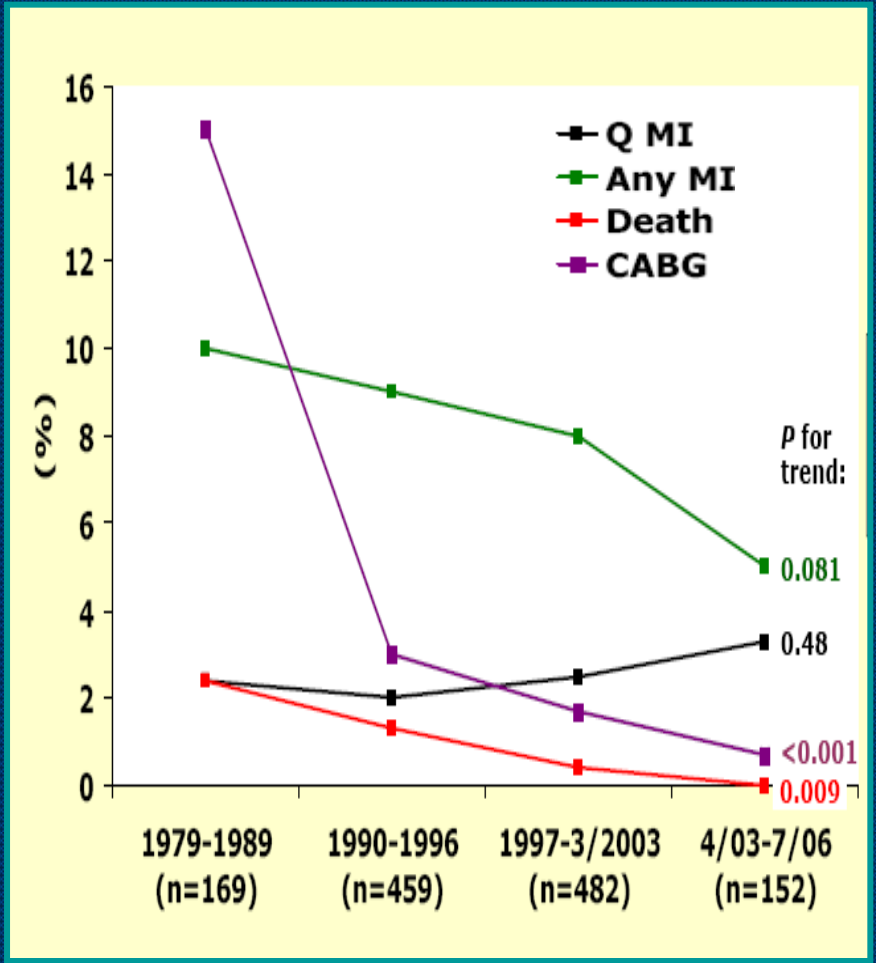
In-hospital Complications in Matched CTO & Non-CTO Angioplasty Cohorts

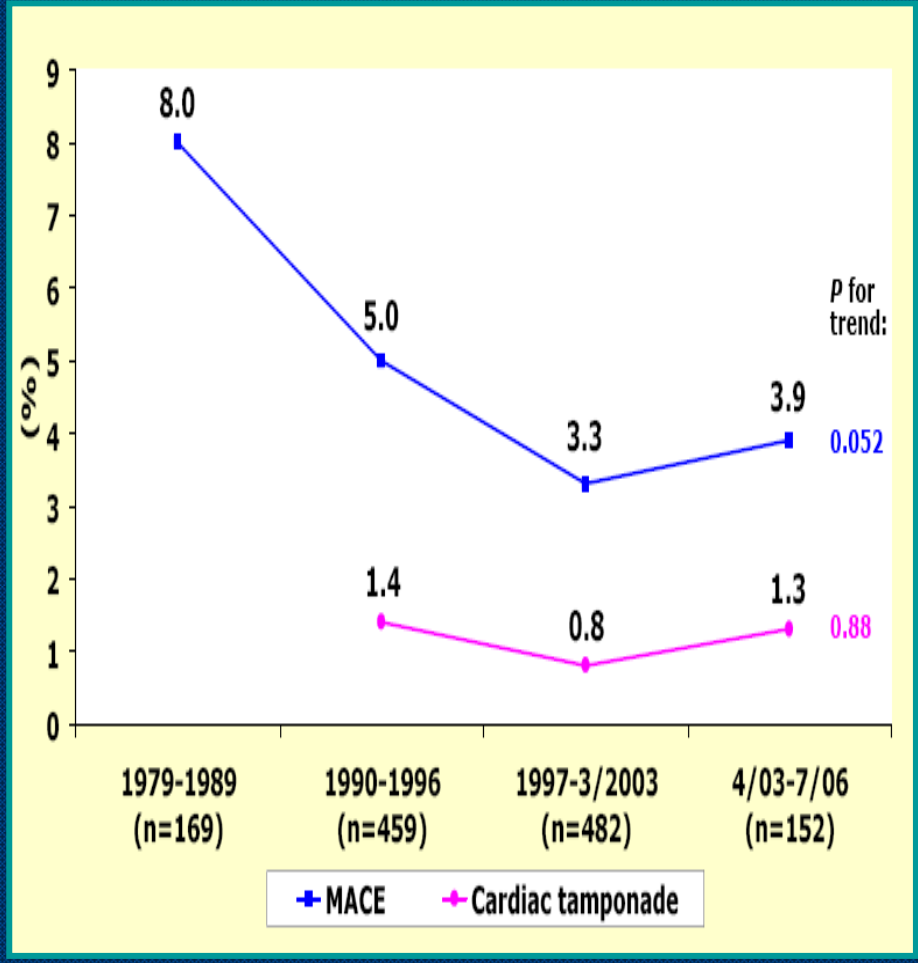


Suero JA, et al. JACC 2001

PCI of CTO Is *NOT* Completely Safe:

25-Yr Experience from the Mayo Clinic (In-Hospital Outcomes)





Prasad A, et al. JACC 2007

The Interest in PCI for CTO is Growing ..

- This leads to introduction of “more aggressive” devices & techniques
- Potentially may induce more complications
- Risk of complications in most cases is dependent on the operator’s skill, but may also be also related to the level of “aggressiveness” of the approach.
- Certain types of complications can be anticipated, but more often they are unexpected ...

Ellis' Classification of Perforation

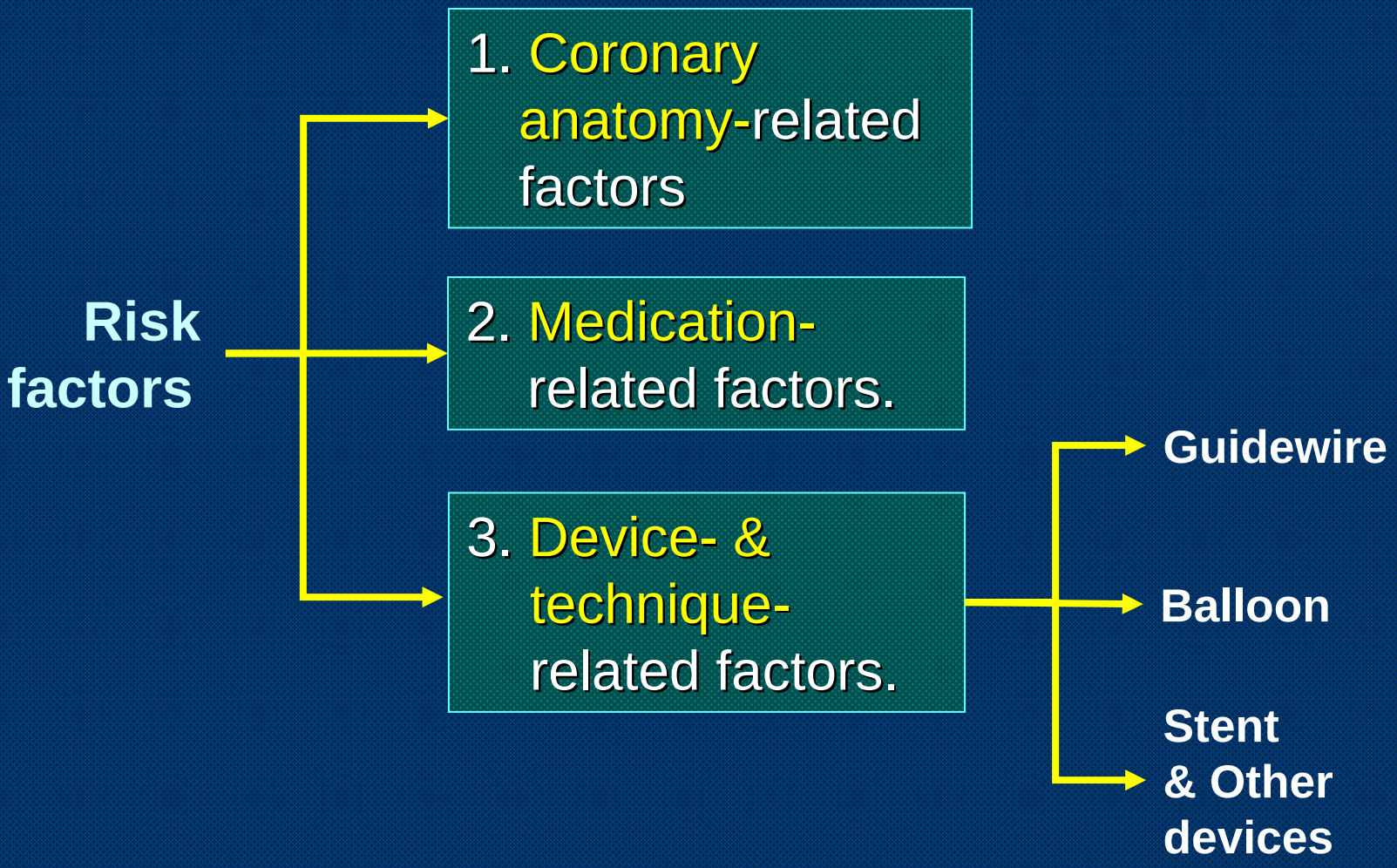
Type 1: Extraluminal crater without extravasation.	Usually without consequence, although it has been reported to result in pericardial effusion
Type 2: Pericardial (subtype A) or myocardial (subtype B) blush without contrast jet extravasation.	At the site of angioplasty or distant if it is induced by GW vessel penetration
Type 3: Extravasation through **frank (> 1 mm) perforation**	Development of **pericardial effusion, tamponade & hemodynamic compromise** (unless urgently treated)
Type 4: Perforation into an **anatomic cavity chamber**	Does not require any treatment

Diagnosis

- Usually easy & made immediately at the time of PCI.
- Fluoroscopy:
  - Very useful to detect & monitor the progression pericardial effusion in the cathlab.
  - ***Best*** method to guide needle puncture & pericardial drainage in case there is imminent tamponade.

- *Late* pericardial effusion is usually a GW induced perforation (often detected only after an echocardiographic examination in the CCU)
- Perforation may also be accompanied by myocardial ischemia due to a coronary occlusion at the site of perforation.

Risk Factors



1. Coronary Anatomy Related Risk Factors

- Risk higher in tortuous, calcified or small vessel. Perforation may occur either in the CTO segment, epicardial or collateral channels.
- In calcified lesion:
  - MSCT is very helpful to assess the CTO course & length, but also extent & site of calcification
  - High pressure inflation may induce perforation
- Perforation of tortuous atrial or epicardial collaterals is more difficult to treat. It is generally not recommended to perform balloon dilatation in the epicardial collateral channels

1. Coronary Anatomy Related Risk Factors

- Small vessel (ie: septal perforators):
  - Easily perforated by GW or if excessive force is applied to advance a balloon / device (i.e. Tornus) through a vessel kink (to minimize kinking, use support wire)
  - For septal channel dilatation, use very small balloon (≤ 1.5 mm) with low pressure inflation (≤ 4 atm).
  - Septal channel perforation may not necessarily be serious, but it may also induce large intramyocardial or subepicardial hematoma.

2. Medication Related Factors

- Not directly related to the risk of perforation, but may increase the complexity of management in case of pericardial effusion or may promote late pericardial effusion.
- GP IIa/IIIb inhibitor not recommended before successful CTO crossing & stent ready to be implanted
- Unfractionated heparin is still the best drug for anticoagulation (Low molecular weight heparin, fondaparinux, or bivalirudin cannot be effectively be neutralized by protamine sulphate).

3. Device & Technique Related Risk Factors:
Guidewires

- Careful GW handling important in using:
  - More powerful, stiff, sharp or hydrophilic GWs. Apply step-by-step increase in GW stiffness (ie: start with intermediate GW before using the Miracle or Conquest-Pro series).
  - Special techniques such as parallel wire, see-saw, or retrograde technique.

- Watch the tip:
  - If there is buckling of the GW, restricted tip movement, or resistance to advancement, it may have entered a false lumen (→ withdraw & reposition)

3. Device & Technique Related Risk Factors:
Balloon

- Size of an artery is difficult to assess if there is no distal flow :
  - Use of oversized balloon may induce perforation, esp. in a dissected vessel.
  - Bilateral coronary injection technique & IVUS is helpful.
- Balloon inflation within a false lumen may result in coronary rupture, although this is actually part of some of the advanced techniques (STAR, CART, & Reversed CART techniques).
- The use of high pressure balloon inflation in a very hard or heavily calcified CTO lesion may induce perforation:
  - Knowledge of the balloon material & the specific rated & actual burst pressure is essential
  - Pinhole balloon rupture can easily cause vessel rupture

3. Device & Technique Related Risk Factors:

Other Devices

- Perforation caused by stenting is not very common, but may occur after excessive overdilatation or after implantation of an oversized stent compared to the vessel caliber.
- The use of excimer laser (ELCA) & rotablation have been reported to occasionally cause perforation
- Pulling out of Tornus device entrapment within the CTO site may induce the GC to jump into the vessel resulting in bad proximal vessel dissection.

Management: 1. Sealing of Perforation

- Temporary sealing with an inflated balloon:
  - Immediately placed at the perforation site – even prior to pericardiocentesis, placement of an IABP or CPR
  - Inflated at the lowest pressure to promote hemostasis, usually < 5 atm.
  - Repeated injections of contrast medium is advisable to help detect the presence of residual extravasation.
- To reduce prolonged myocardial ischemia, perfusion balloon may be used if prolonged balloon inflation is necessary.

Management: 1. Sealing of Perforation

- Reversal of anticoagulation & restoration of platelet function
  - May not be necessary if sealing of perforation can be rapidly performed.
  - Protamine can be safely administered to reverse unfractionated heparin effect without increasing the risk of acute stent thrombosis (target of ACT = < 150 seconds).
  - Complete reversal of anticoagulation is not possible for pts treated with LMWH, fondaparinux or bivalirudin.
  - The effect of abxicimab can be reversed by platelet transfusion (6-10 units), but there is no antidote for eptifibatide or tirofiban.

- After successful drainage, oral antiplatelet therapy with aspirin, clopidogrel or cilostazol should be reinstituted for stented pts.

Management: 1. Sealing of Perforation

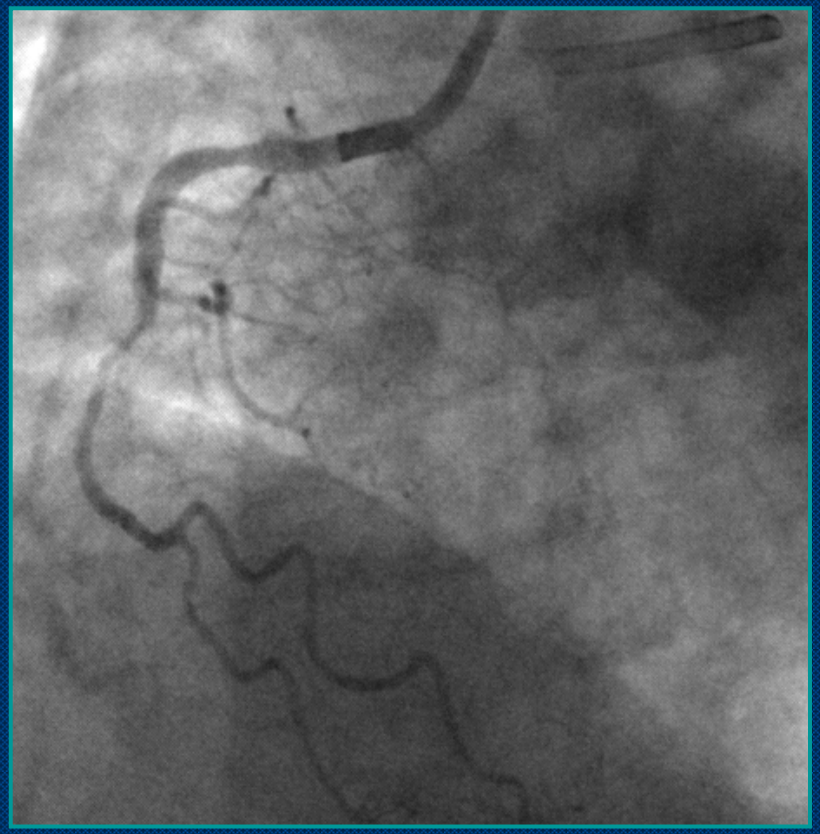
- Permanent sealing of perforation can be achieved by PTFE covered stent implantation. Covered stent is bulky & difficult to use in distal or tortuous vessels.
- Other choices are: “make-shift” covered stent, autologous venous-covered stents & radial artery graft covered stents

- Embolization (using either thrombin, gelfoam, microcoil, clotted autologous blood or even fat tissue) is a reasonable strategy if the perforation is located in a the distal segment or side branch of the vessel, or in relatively small vessel .
- Only in the very extreme situations when there is large vessel rupture with severe ischemia, hemodynamic compromise, & arterial hemorrhage that persists despite nonoperative measures, emergency surgery should be performed.

2. Restoration of Hemodynamic Compromise

- If after complete sealing of the perforated vessel there is no increase in the amount of effusion & no hemodynamic instability after a sufficient period of observation (i.e. 30-60 minutes), there is no need for pericardiocentesis.
- In the presence of hemodynamic compromise, fluoroscopy guided (& not echo-guided) pericardiocentesis followed by catheter drainage should be immediately performed
- Continuous pericardial catheter drainage should remain in place for 1-2 days & can be removed after there is no more fluid reaccumulation (shown by the absence of increasing fluid level in the collecting bag & by echocardiography).

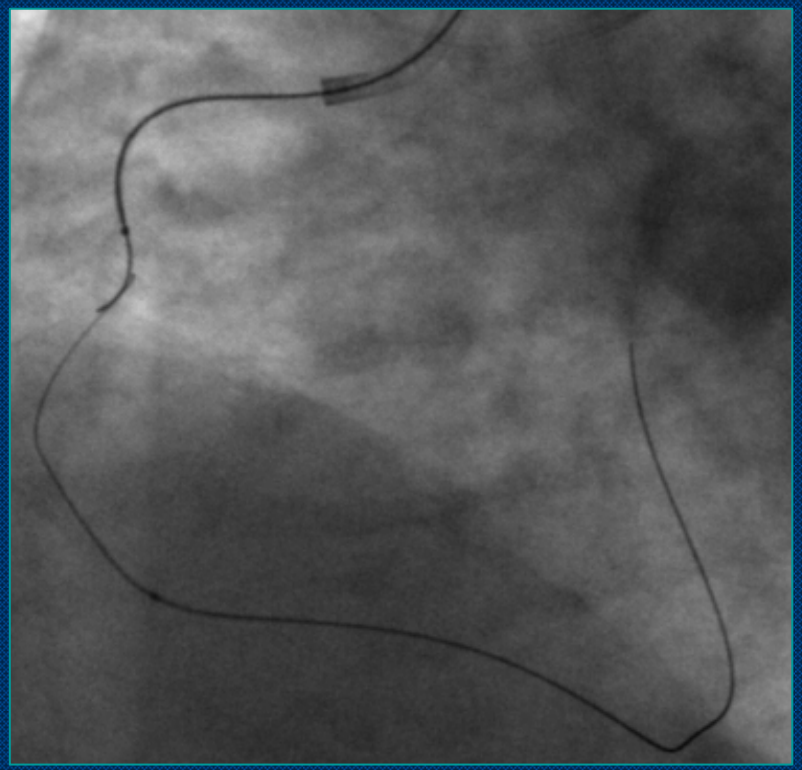
Case 1: CTO perforation in a pt treated with the *retrograde technique (1).*



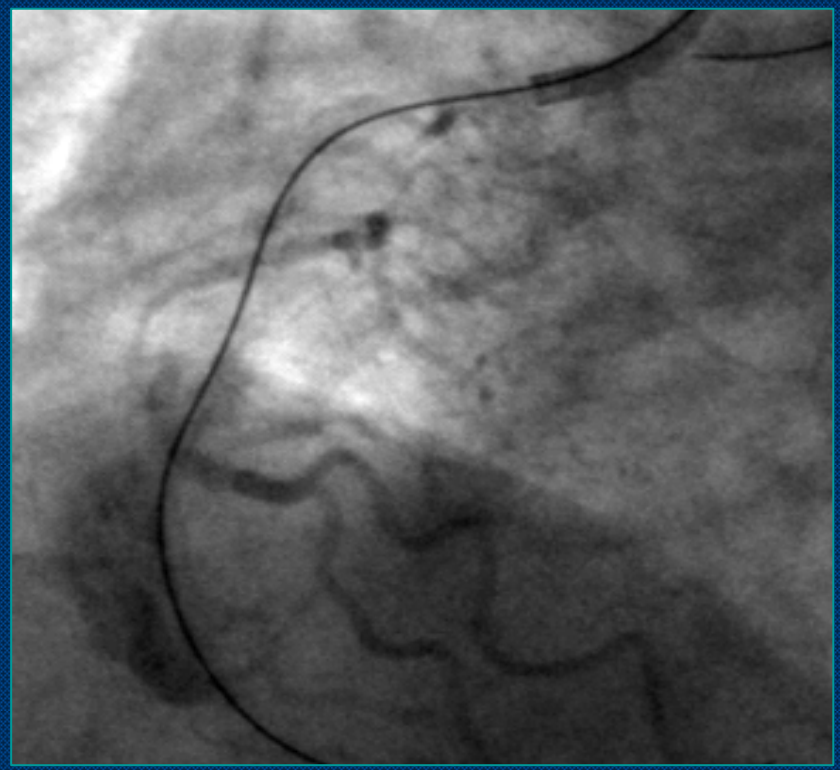
CTO in the proximal RCA. Note absence of stump and presence of side branch at the proximal end of the CTO

Septal and epicardial channels from the LAD

Case 1: CTO perforation in a pt treated with the *retrograde technique (2).*

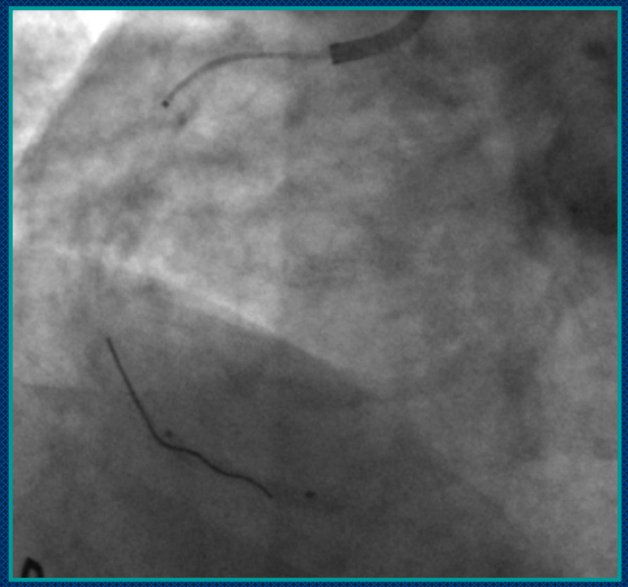


Retrograde approach using knuckle wire technique was applied



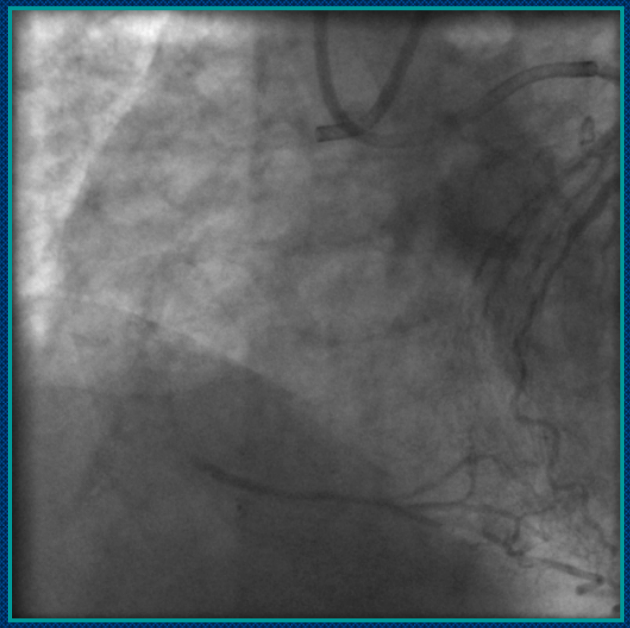
Perforation induced by a 1.5 mm antegrade balloon

Case 1: CTO perforation in a pt treated with the *retrograde technique (3).*



As use of covered stent was impossible, **gelatine sponge** was injected **retrogradely** via the inner lumen of the 2.25 mm **retrograde balloon** . This was followed by another injection via the inner lumen of a 2.25 mm OTW balloon placed **antegradely** in the proximal RCA

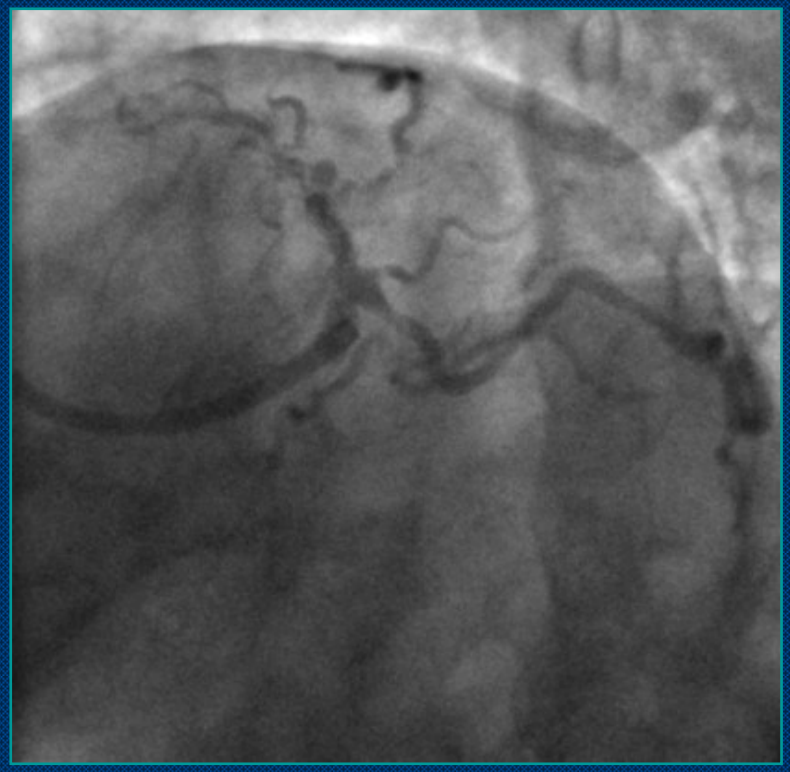
Proximal RCA injection showed no more extravasation



Retrograde injection confirmed successful control of perforation

Case 2: CTO perforation in a patient treated with the *antegrade technique (1).*

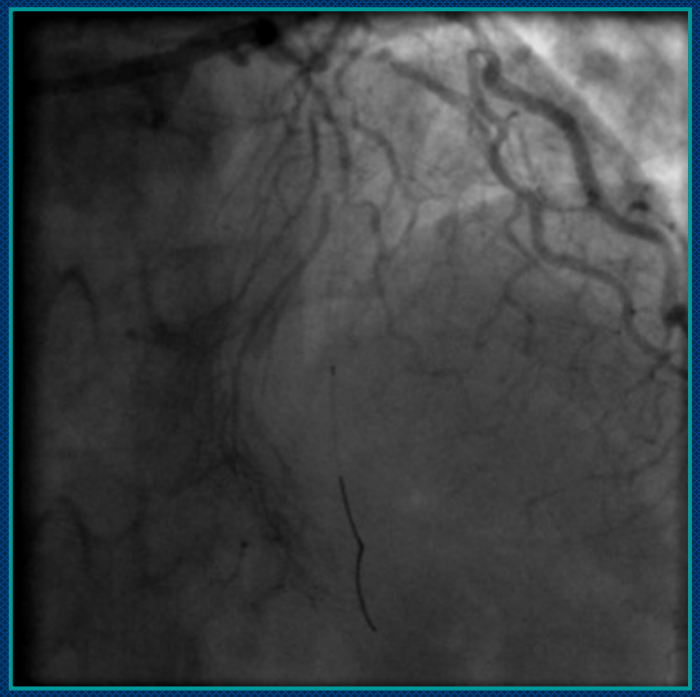
BBG, male, 59 yrs, silent ischemia (CAD detected on MSCT)



TRANS-RADIAL APPROACH (7F GC):
Distal LM stenosis (25%)
Heavily calcified, diffusely stenotic proximal LAD stenosis followed by CTO

Sharp LCX take off with significant stenosis in the tortuous, calcified proximal segment

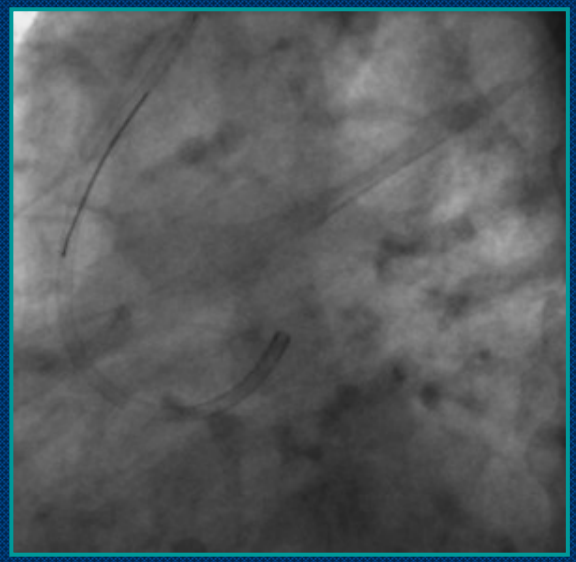
Case 2: CTO perforation in a patient treated with the *antegrade technique (2)*



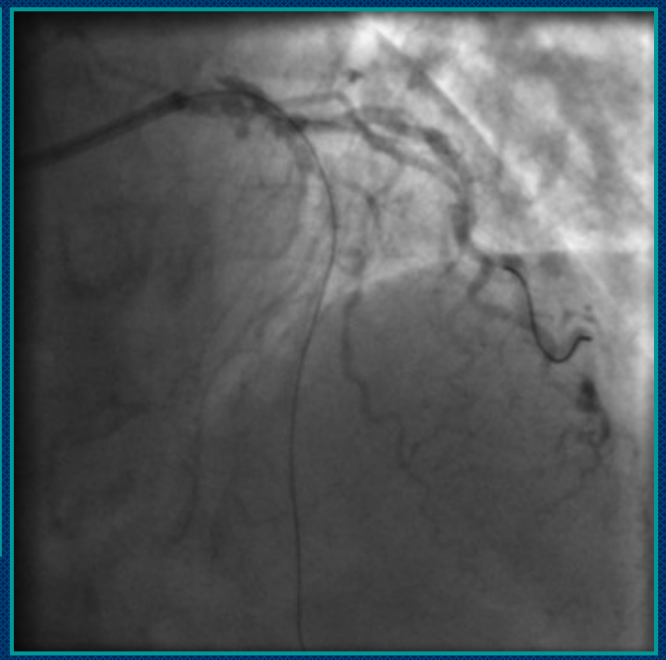
Balloon could not cross the CTO & ruptured in the proximal LAD created bad dissection. Tornus & Tornus 88 were stuck in the mid-LAD. *Tornus 88 was trapped & very difficult to remove*. Figure showed appearance after removal of Tornus 88.

Catheter induced LM & LAD dissection (when forcefully pulling the Tornus 88 out, GC jumped into the LM)

Case 2: CTO perforation in a patient treated with the *antegrade technique (3)*



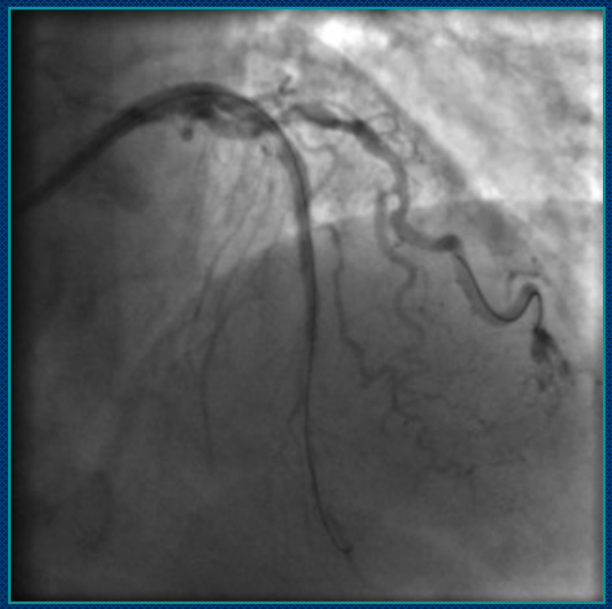
Patient had severe chest pain, became agitated, developed ST elevation. All access lost



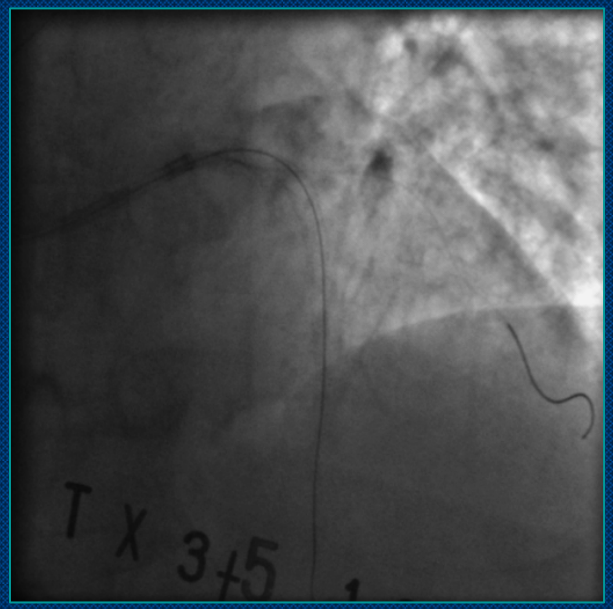
After re-dilatation of the LM-LAD, with difficulties (LM & proximal LAD dissection, followed by CTO in midsegment), GW could cross the whole LAD

LCX was a very important vessel & stented first.

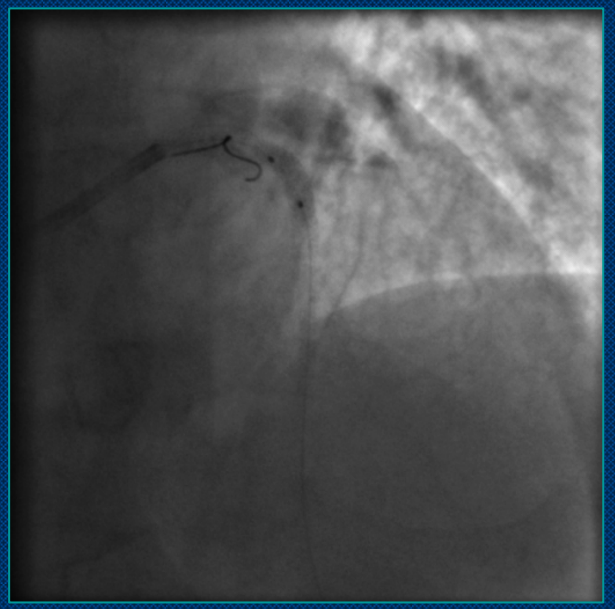
Case 2: CTO perforation in a patient treated with the *antegrade technique (4)*



After stepwise dilatation of mid-proximal LAD, 3 overlapping Taxus (2.25x16 mm, 2.25x24 mm, 2.75x24 mm) were implanted in LAD & one Biomatrix 3.5x18 mm in LM-LAD. Suboptimal result in the prox. LAD

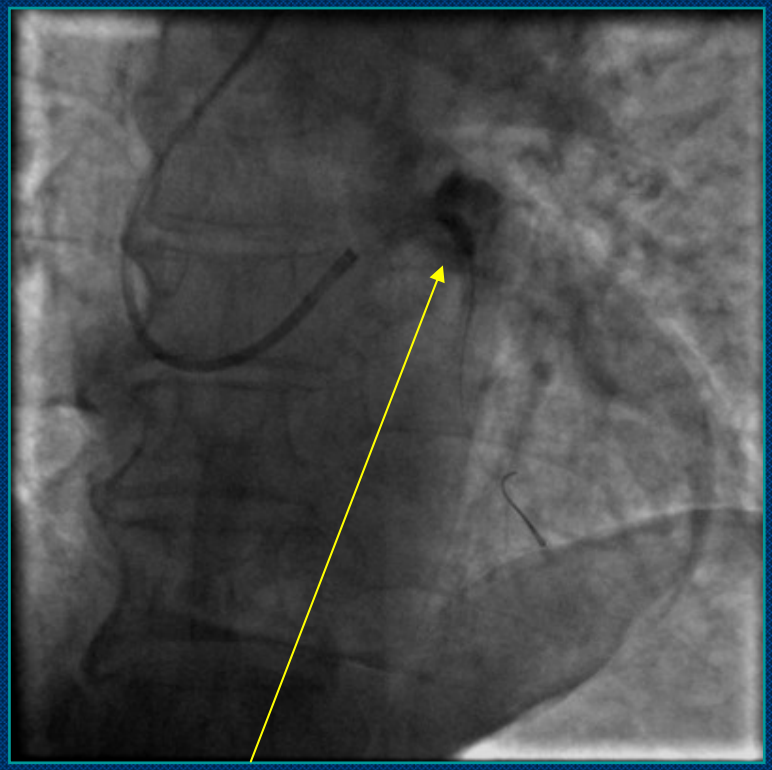


Air embolization & perforation after implantation of another Taxus stent & high pressure dilatation. Chest pain became worse, ST markedly elevated

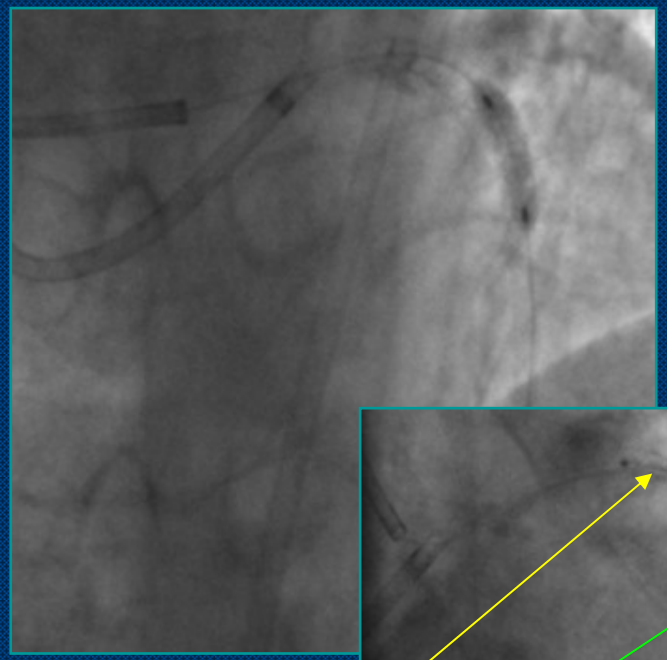


Persistent leak even after implantation of covered stent. Second covered stent could not be introduced with the buddy wire technique. Buddy balloon technique could not be applied as the GC (7C) was too small

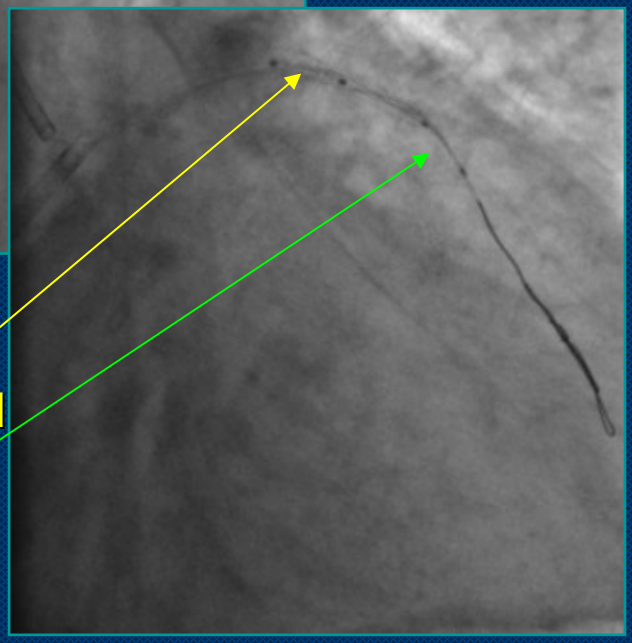
Case 2: CTO perforation in a patient treated with the *antegrade technique (5)*



Temporary sealing with balloon. Pericardial effusion noted to increase.

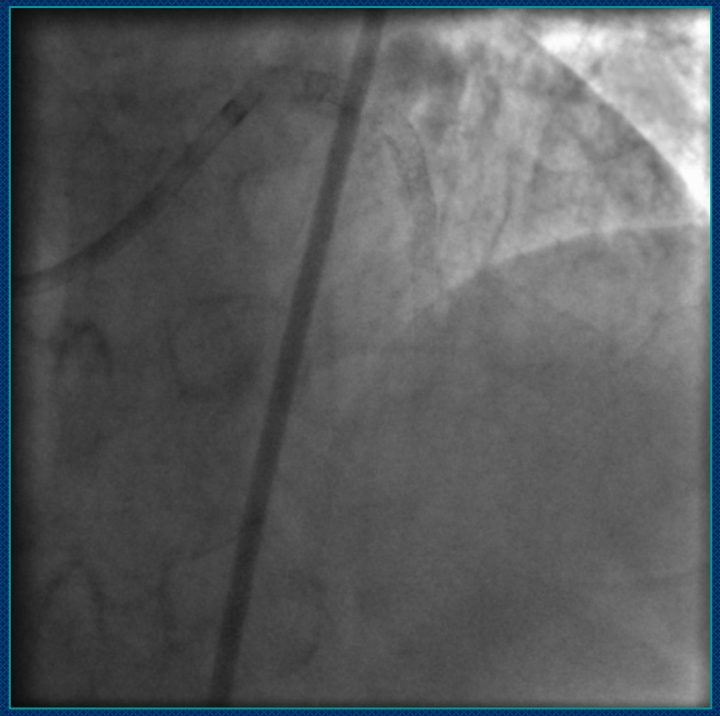


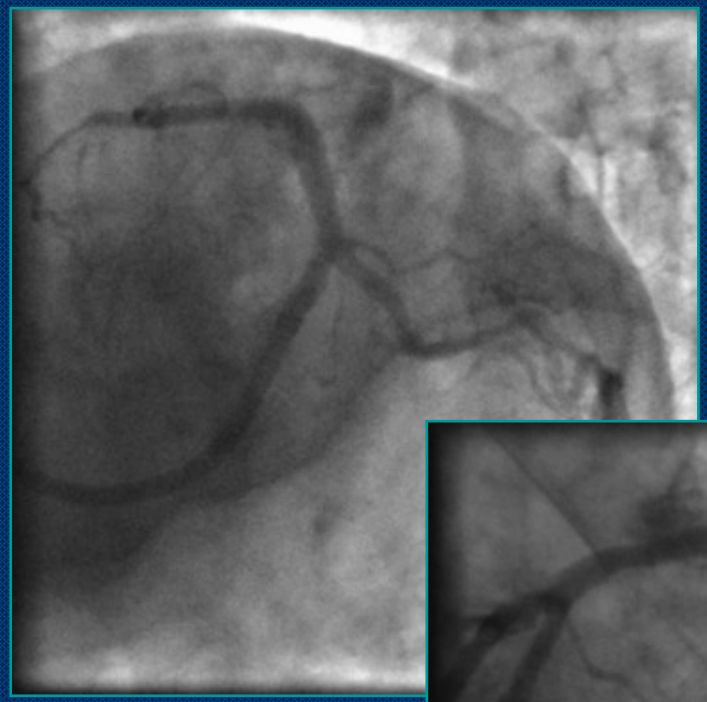
2nd GC introduced via femoral approach

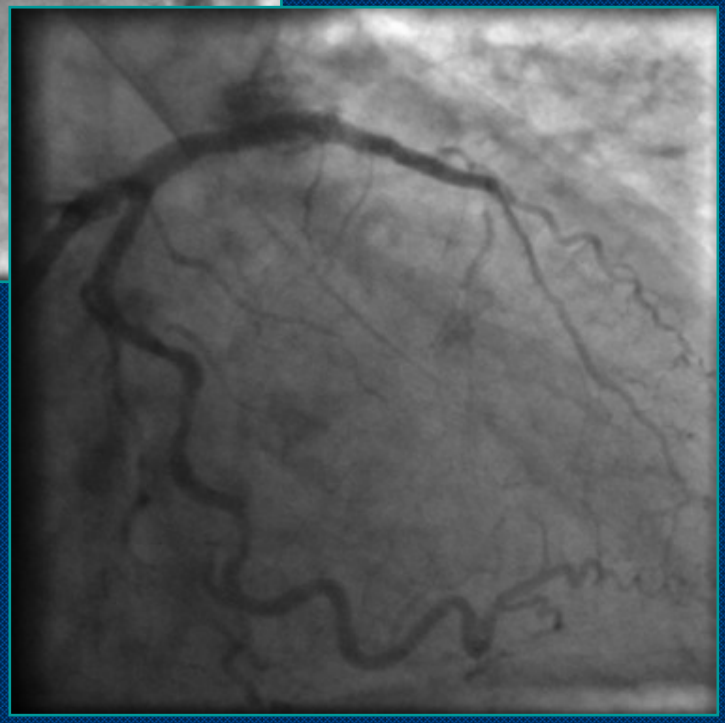


2nd covered stent introduced with the buddy balloon technique

Case 2: CTO perforation in a patient treated with the *antegrade technique (6)*







GOOD FINAL RESULT !!!

Minor non-flow limiting dissection in mid-LAD left alone