Coronary Artery Perforation

- How to cope with a desperate situation -

Sunao Nakamura MD PhD

FACC, FESC, FAHA, FSCAI

Shotaro Nakamura MD, Naoyuki Kurita MD, Hisaaki Ishiguro MD, Satoko Tahara MD
Masaaki Okutsu MD, Tomohiko Sato MD, Toru Naganuma MD, Satoru Mitomo M.D.
Hiroyoshi Kawamoto MD, Kentaro Tanaka MD, Satoshi Matsuoka MD, Tatsuya Amano MD,
Hiroaki Nakajima MD, Hirokazu Onishi MD, Kenjiro Tani MD, Yusuke Watanabe MD,
Koji Hozawa M.D., Toru Ohuti M.D., Hiroto Yabushita MD,

The New Tokyo Hospital ; Japan Tokyo

1. Shape of Coronary Perfpration

1. Classification

Coronary Perforation

Ellis classification: 1994 Circulation

Type Ⅰ	Extraluminal crater without extravasation
Type Ⅱ	Pericardial or myocardial blush without contrast jet Extravasation
Type Ⅲ	Extravasation through frank (>1 mm) perforation
Cavity spilling	Perforation into an anatomic cavity chamber, Coronary sinus, etc

Ellis SG, et al Circulation 1994; 90:2725-2730












1. **Shape of Coronary Perforation**

2. Statistics

Coronary Perforation in the Drug Eluting Stent era : incidence, risk factors, management and outcome : The UK experience

C Hendry et al. EuroIntervention 2012;7:79-86

Reason Why...

Table 4. Mechanism of perforation.

Device	Total	Class II	Class III
Guidewire	10	2	8
Stent	14	1	13
Cutting balloon	5	3	2
Post-dilatation	7	1	6
Predilatation	6	1	5
Late	2	0	2

All incidence:
About 0.3%

Table 3. Angiographic characteristics of perforated vessel.

Site of coronary perforation	
Left main	0
Left anterior descending	22 (50)
Diagonal	4 (9.1)
Circumflex	1 (2.27)
Obtuse marginal	3 (6.81)
Right coronary artery	11 (25)
Saphenous vein graft	2 (4.54)
Left internal mammary artery	1 (2.27)
Lesion tortuosity	
Severe (<45 degrees)	1 (2.3%)
Moderate (45-90 degrees)	18 (40.9%)
Mild (>90 degrees)	25 (56.8%)
Lesion complexity	
A	0
B1	0
B2	4 (9%)
C	40 (91%)
Perforation severity (Ellis class)	
II	8 (18%)
III	36 (82%)
IIICS	0

Coronary Perforation in the Drug Eluting Stent era : incidence, risk factors, management and outcome : The UK experience

C Hendry et al. EuroIntervention 2012;7:79-86

Perforation Type	N	Death, %	EmerCABG (%)	Drainage (%)	Coveredstent (%)	Coil(%)
II	8 (18%)	0	0	0	50	0
IIICS						
III	36 (82%)	19	8 ✔	44 ✔	56	6

44 of 12729 procedures (0.56%)

Age (P<0.001), Females (P=0.001), Calcification (P=0.004),

CTO (P<0.001), ROTA (P<0.001), Cutting Balloon (P<0.001)

Incidence, Risk factors and Outcome

Incidence; 0.1-0.5%　　Mortality; 9-15%
Risk factors; high-age, women, CTO, debulking, calcification

	No.	Period	Incidence	Grade > II	Mortality	Risk factors
Friedrich et al 1994	4196	1986–1991	14 (0.12%)	14 (0.12%)	9.1%	---
Ajluni SC et al 1994	8932	1988–1992	35 (0.4%)	27 (0.4%)	9%	Over-sizing of device
Ellis et al 1994	12900	1990–1991	62 (0.5%)	47 (0.4%)	41%	Women, age
Gruberg et al 2000	30746	1990–1999	88 (0.29%)	---	10%	Women, atheroablative devices
Dippel et al 2001	6214	1995–1999	36 (0.58%)	36 (0.58%)	11.1%	Atheroablative devices, HF
Gunning et al 2001	6245	1995–2001	52 (0.8%)	---	11.5%	---
Fasseas et al 2004	16292	1990–2001	95 (0.58%)	78 (0.48%)	7.4%	Atheroablative devices, women, type C, CABG
Javaid et al 2006	38559	1996–2005	72 (0.19%)	58 (0.15%)	17%	---
Shimony et al 2009	9568	2001–2008	57 (0.59%)	50 (0.52%)	7%	Age, HT, CTO, calc, CABG, ACS, RCA, femoral approach
Ben-Gal et al 2010	13466	2004–2008	33 (0.25%)	26 (0.19%)	12%	---
Hendry et al 2012	12729	2004–2008	44 (0.56%)	44 (0.56%)	15.9%	Age, women, calcification, CTO, atheroablative devices, Cutting balloon

Prevalence and outcomes of coronary artery perforation during percutaneous coronary intervention : from UK national Data

Guttman Op et al. EuroIntervention 2017 Aug 4;13(5)

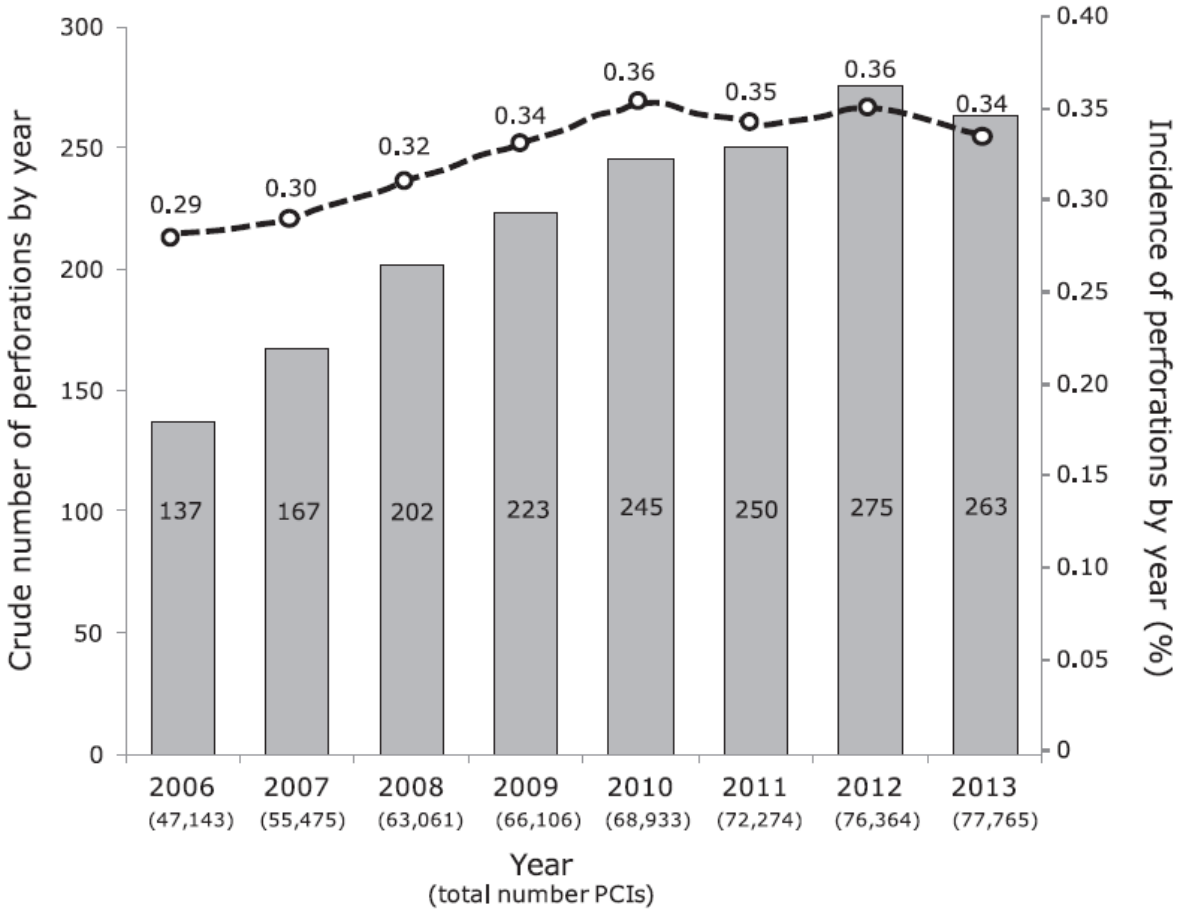
Table 1. Patient and procedural characteristics.

Variable	Perforation (n=149)	No perforation (n=39,115)
Age (years)*	70.45 (60.30-77.52)	68.2 (58.4-76.21)
Male	103 (69.1%)	30,033 (76.8%)
Hypercholesterolaemia	68 (45.6%)	18,575 (47.5%)
Hypertension	73 (49.0%)	18,443 (47.2%)
Smoker	32 (21.5%)	8,287 (21.2%)
Diabetes mellitus	27 (18.1%)	7,495 (19.2%)
Previous MI	37 (24.8%)	8,598 (22%)
Previous PCI	32 (21.4%)	7,412 (18.9%)
Previous CABG	20 (13.4%)	2,799 (7.2%)
Stable angina	81 (54.4%)	22,003 (56.2%)
ACS	68 (45.6%)	17,112 (43.8%)
NSTEMI/UA	33 (48.5%)	8,147 (47.6%)
Primary PCI	35 (51.5%)	8,965 (52.4%)
Multivessel disease	29 (19.5%)	7,157 (18.3%)
LVEF <30%	18 (12.1%)	4,568 (11.7%)
Chronic kidney disease	10 (6.7%)	2,263 (5.8%)
Shock at presentation	8 (5.4%)	2,212 (5.7%)

All Incidence:
About 0.38%

Incidence, Determinants, and Outcomes of Coronary Perforation During Percutaneous Coronary Intervention in the United Kingdom Between 2006 and 2013 An Analysis of 527121 Cases From the British Cardiovascular Intervention Society Database:

Tim Kinnaird et al. Circ Cardiovasc Interv. 2016 9:e003449.



Crude numbers and incidence of coronary perforation from 2006 to 2013.

2. The Cases !!

① GW mediated Perforation

Case based approach

Case 1 : GW perforation

due to it’s migration in SB

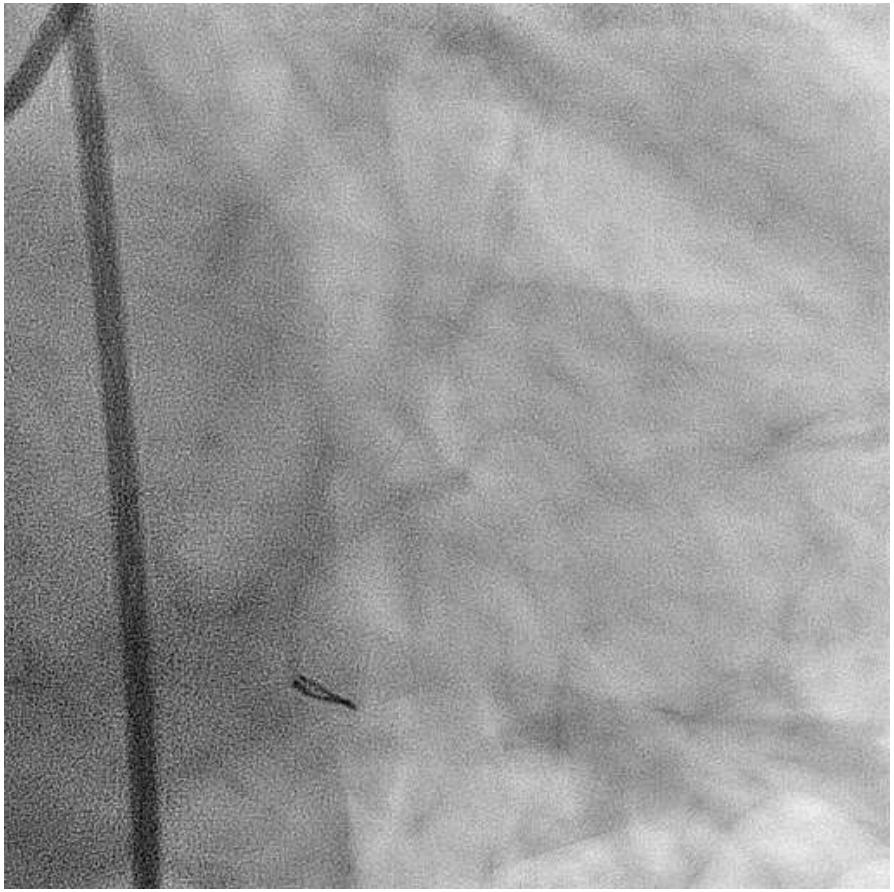
① Coil Embolization

Case 1 : Perforation in distal LCX doe to GW migration in 2006

- Coil embolization for GW perforation 1 -

Wire perforation at distal LCx

Coil embolization via micro-catheter



Case 2 : GW perforation

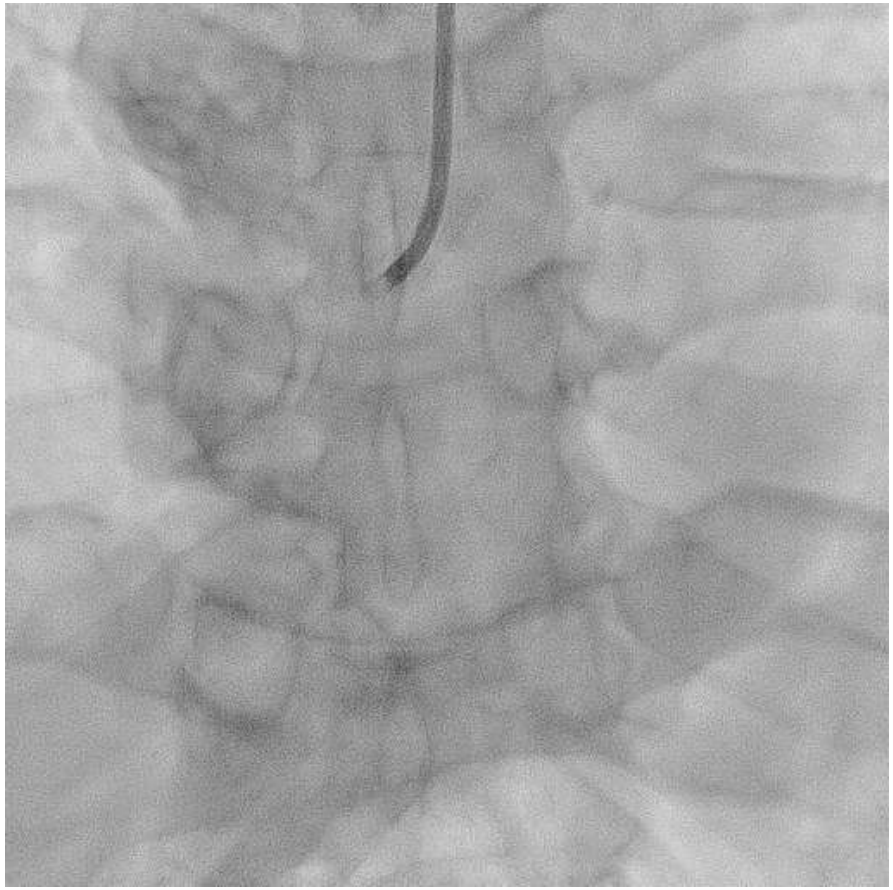
due to it’s migration in SB

② Fat Tissue

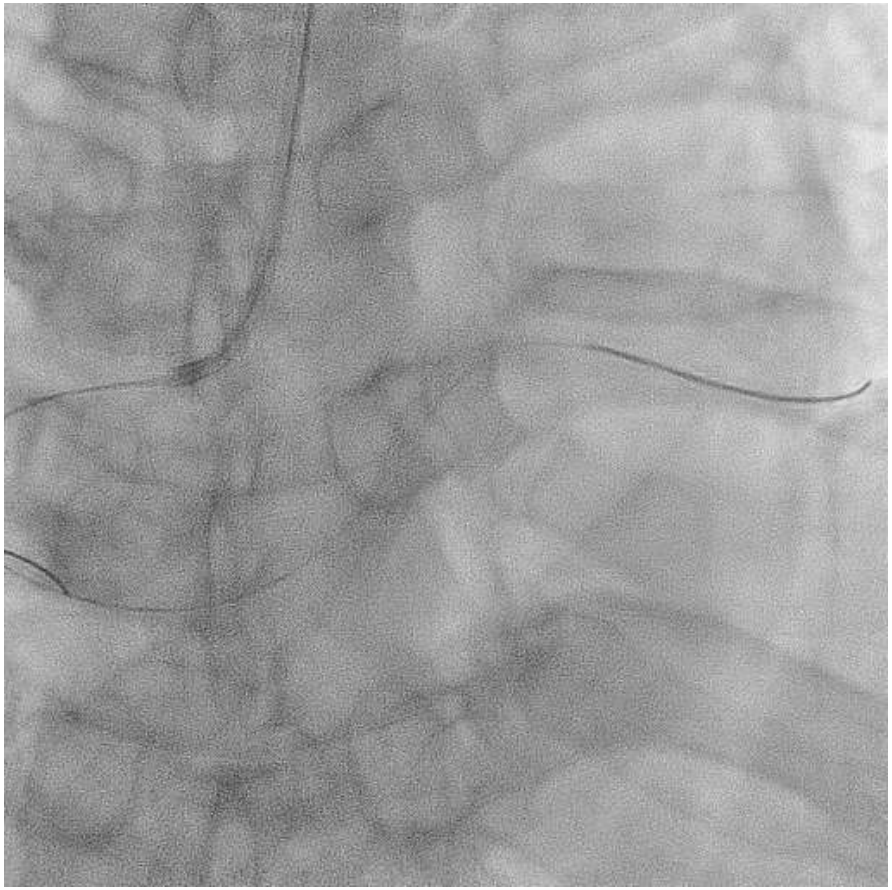
Case 2 : Perforation in RCA distal due to GW migration in 2006

- Fat tissue embolization for GW perforation 1 -

Initial angiography



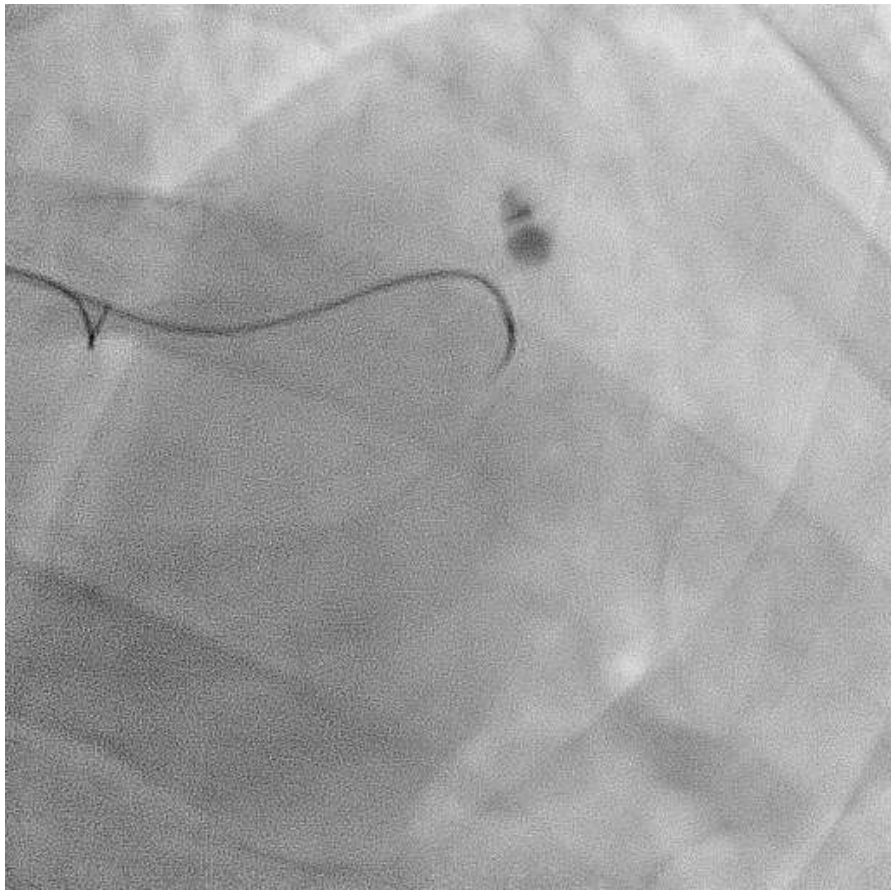
Wire perforation at distal RCA



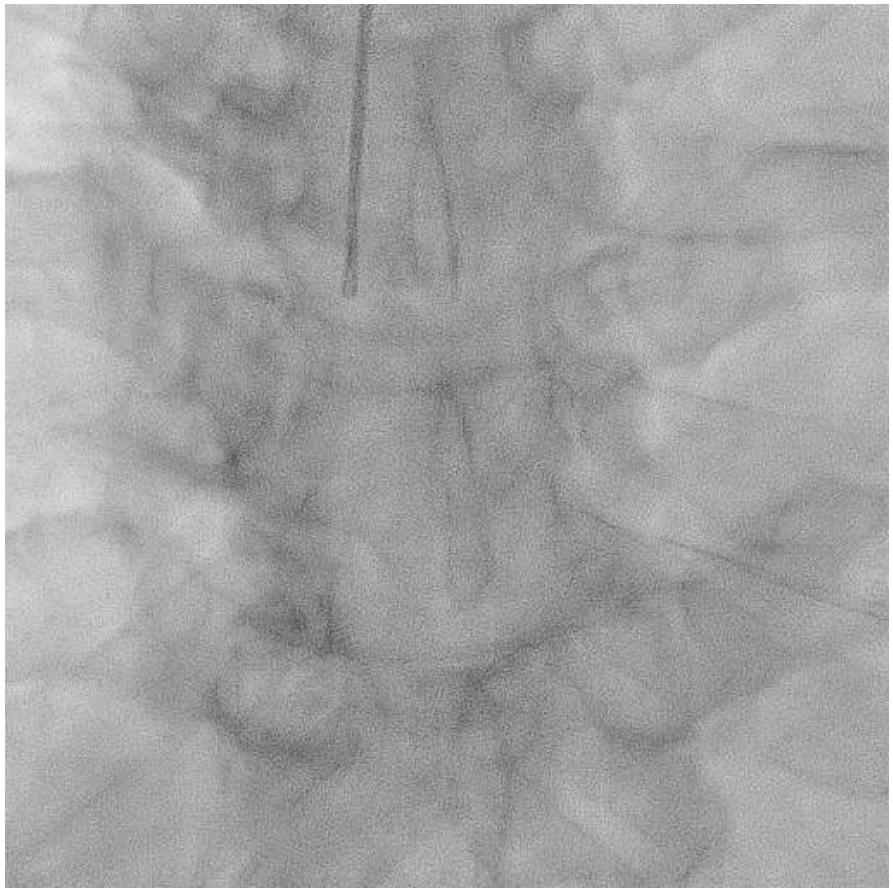
Case 2 : Perforation in RCA distal due to GW migration in 2006

- Fat tissue embolization for GW perforation 1 -

Fat tissue embolization via micro-catheter



Final angiography



Guidewire-Induced Coronary Artery Perforation Treated With Transcatheter Delivery of Subcutaneous Tissue

Hirotaka Oda, et al. Catheter Cardiovasc Interv 2005; 66:369-374

In three cases of small coronary artery perforation by guidewires during percutaneous coronary intervention, coronary leakage continued despite prolonged balloon inflation and reversal of heparin.

Subcutaneous tissue was selectively delivered to perforated vessels by means of micro-catheters in a successful attempt to stop leakage.

This method appears to be extremely effective for treating guidewire-induced perforations of distal coronary arteries.

Case 3 : GW perforation

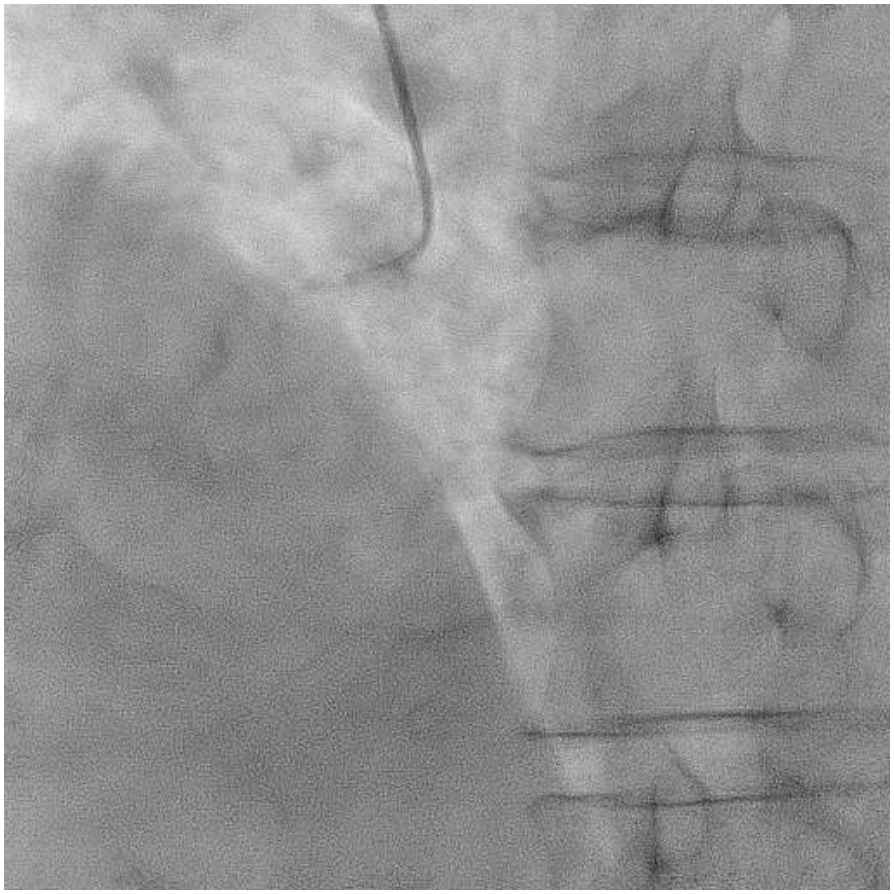
due to it’s migration in SB

② Graft Stent

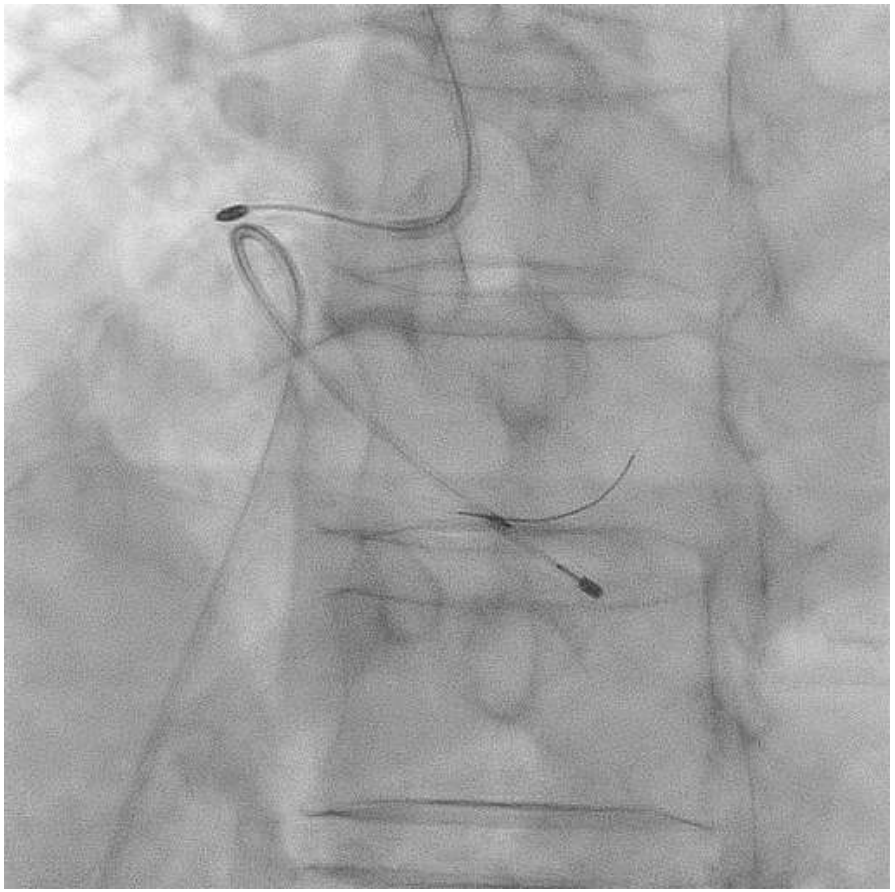
Case 3 : Perforation in RCA distal due to GW migration in 2006

- Graft Stent implant. for GW perforation -

Severely calcified RCA prox. stenosis



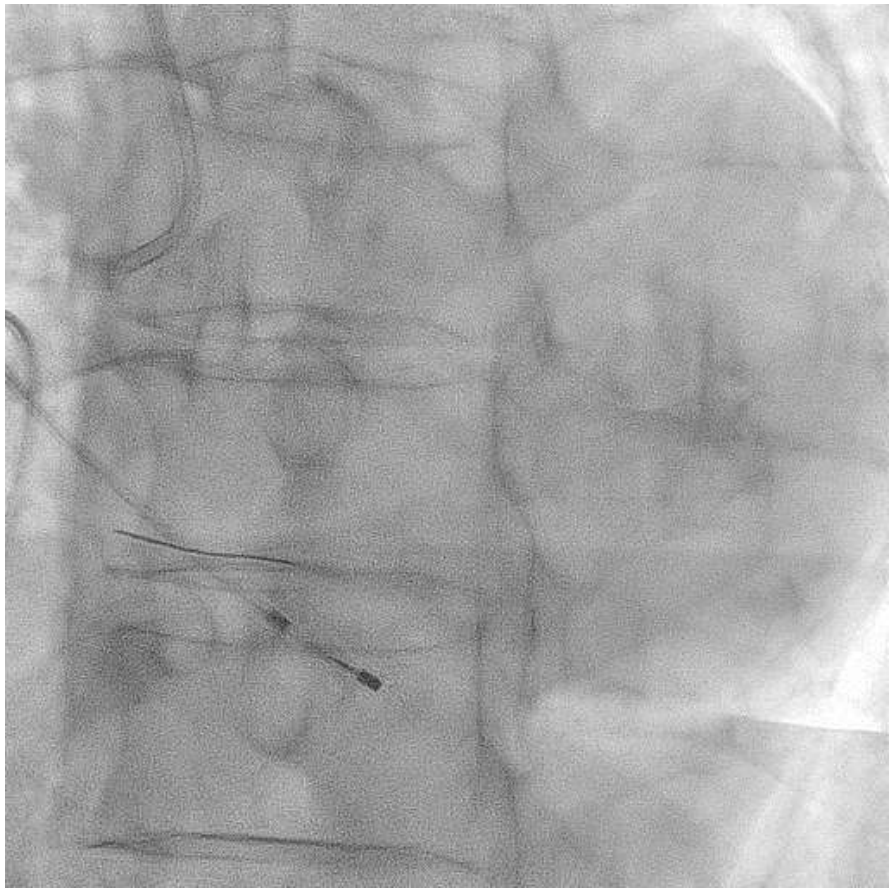
Ablation by Rotational atherectomy



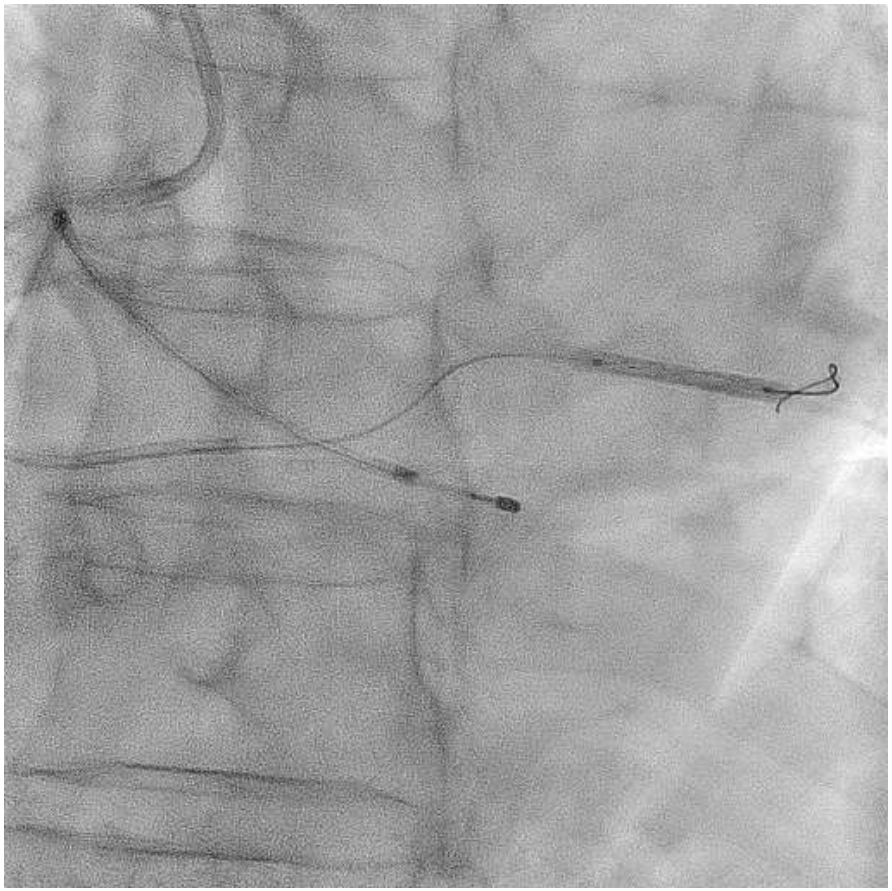
Case 3 : Perforation in RCA distal due to GW migration in 2006

- Graft Stent implant. for GW perforation -

Perforation at RCA distal due to less careful GW manipulation



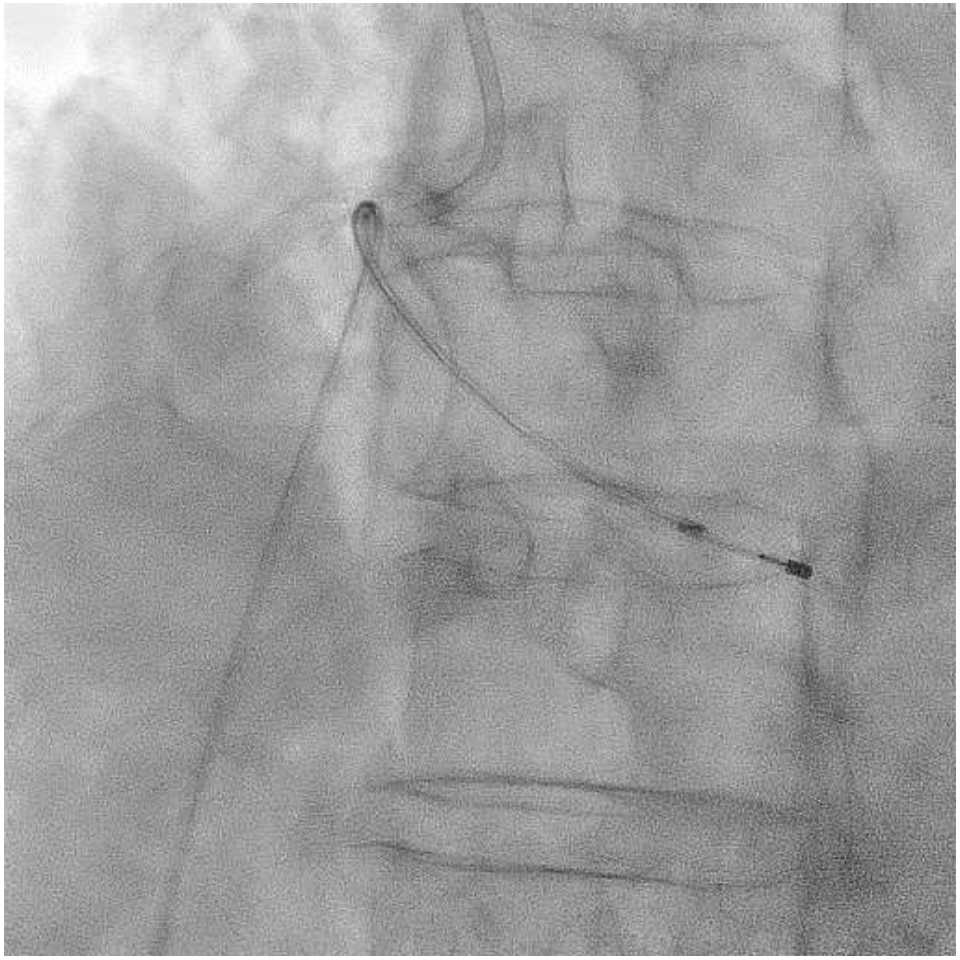
Covered stent implantation



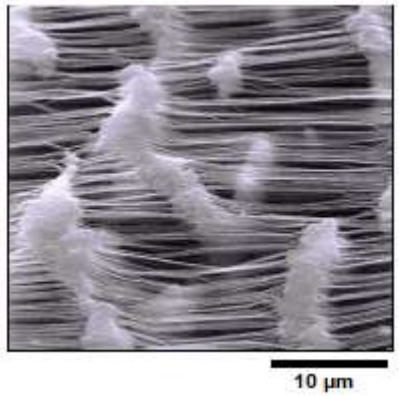
Case 3 : Perforation in RCA distal due to GW migration in 2006

- Graft Stent implant. for GW perforation -

Perforation was sealed by covered stent.



Polytetrafluoroethylene-Covered Stent

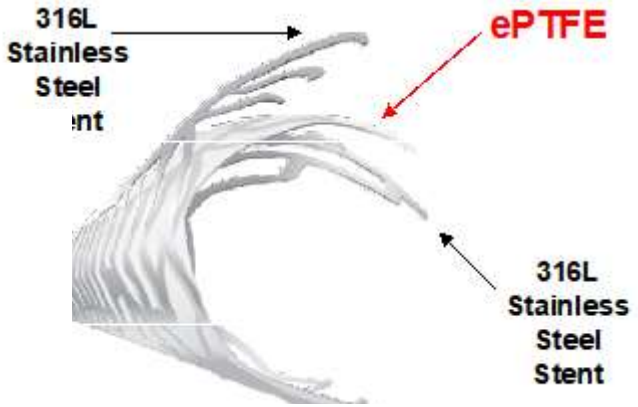


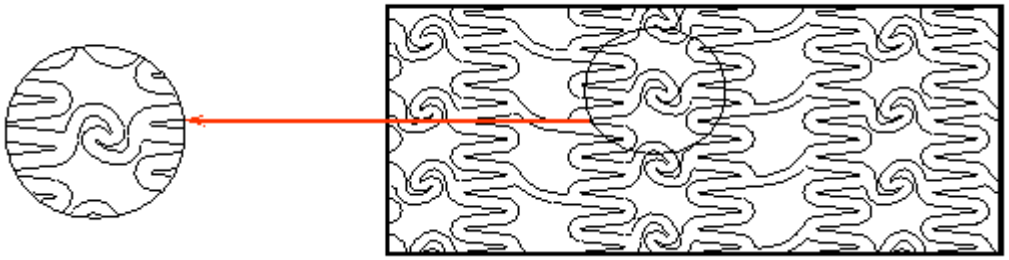
Double layer 319 steel sandwich with ePTFE membrane

Thickness = 260 um

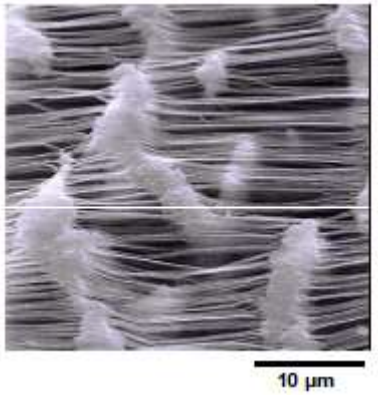
High biocompatibility

multi-hole in membrane





About Graft Stent



double layer 2 stent
in PTFE membrane !!

1. Very reliable, but less trackability
2. Must and Must POST HP Dilatation
3. be able to in the Extension !!
4. Very improved restenosis rate in current version !!
5. Very precise placement is very very essential !!

Compatibility of GRAFTMASTER (2.8 mm, 3.5 mm) for various support catheters

Satoru Mitomo M.D. et al

Support catheter	Compatibility
GuideLiner 5.5 Fr	×
GuideLiner 6.0 Fr	△
GuideLiner 7.0 Fr	○
GuideZilla 6.0 Fr	△
GuideZilla 7.0 Fr	○
Heartraill 4.0 Fr ST01	×
Heartraill 5.0 Fr ST01	○
○＝**Easy** △＝**Possible** ×＝**Impossible** GRAFTMASTER (Abbott Vascular, Santa Clara, CA)	
GuideLiner (Vascular Solutions, Minneapolis, MN) GuideZilla (Boston Scientific, Marlborough, MA) Heartrail (Terumo, Tokyo)	

Case 4 : GW perforation

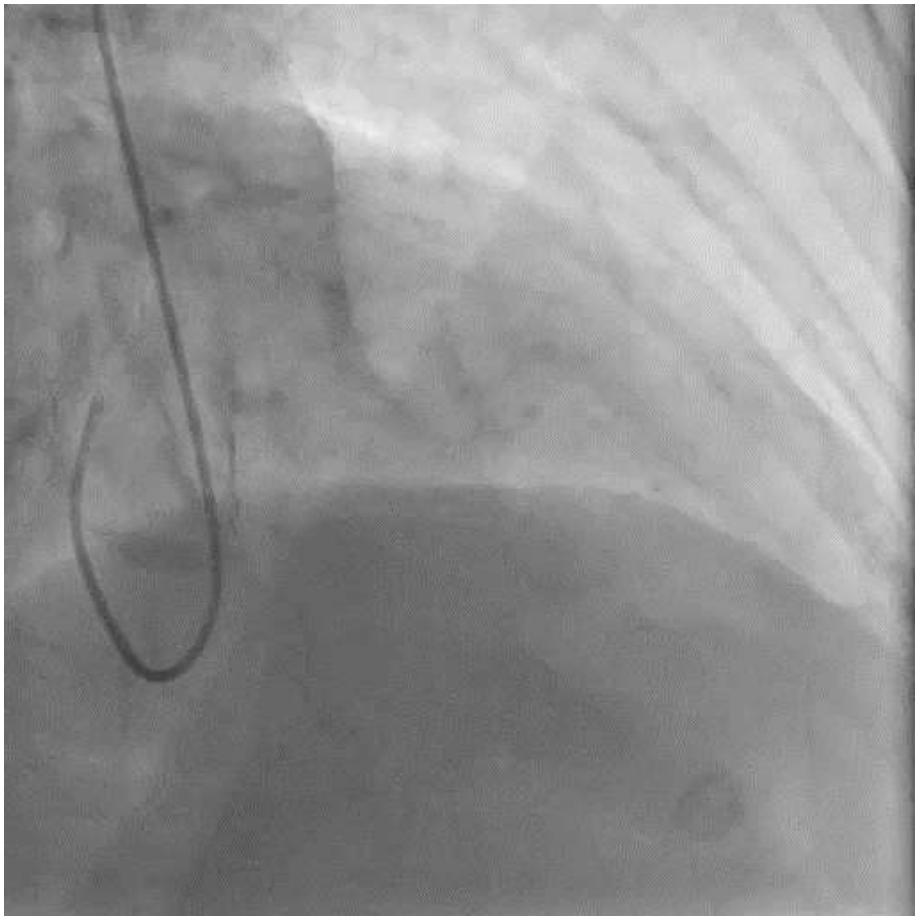
due to it’s migration in SB

④ In case of injury of collateral...

Case 4 : Perforation in sept. due to GW migration in 2008

- Coil embolization for perforation -

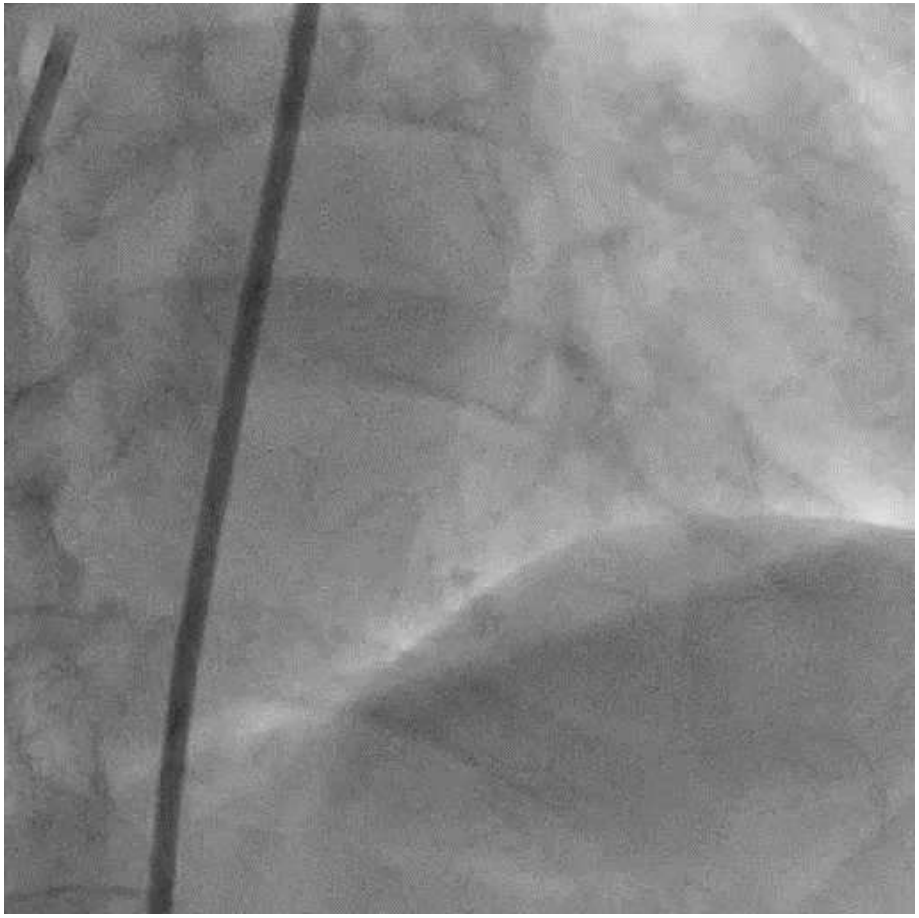
3VD with 2CTO(Very long RCA CTO and LCX CTO)

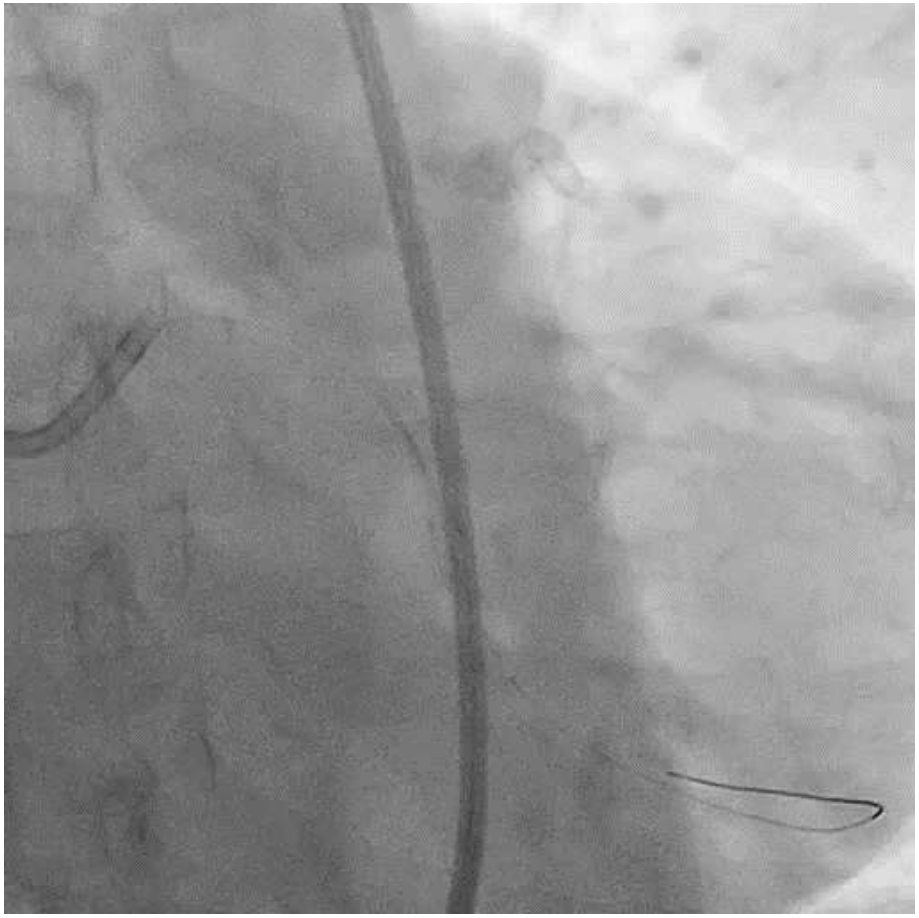


Case 4 : Perforation in sept. due to GW migration in 2008

- Coil embolization for perforation -

After Opening LCX CTO and Stented in LAD, we want to RCA...

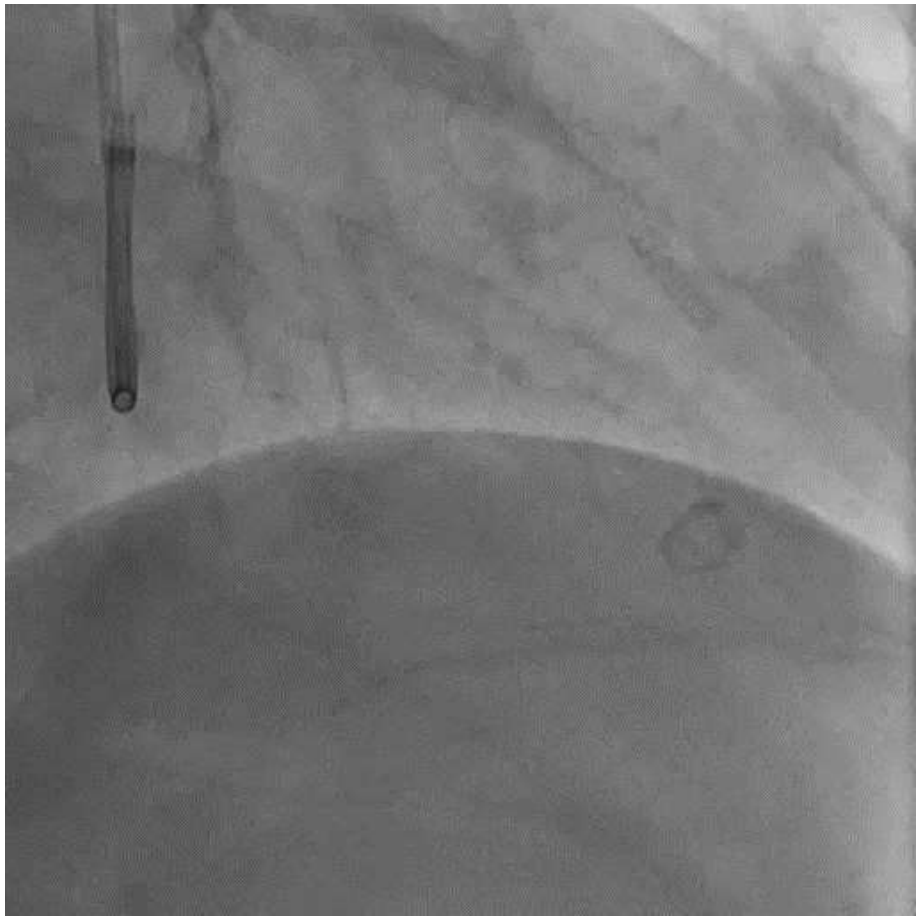


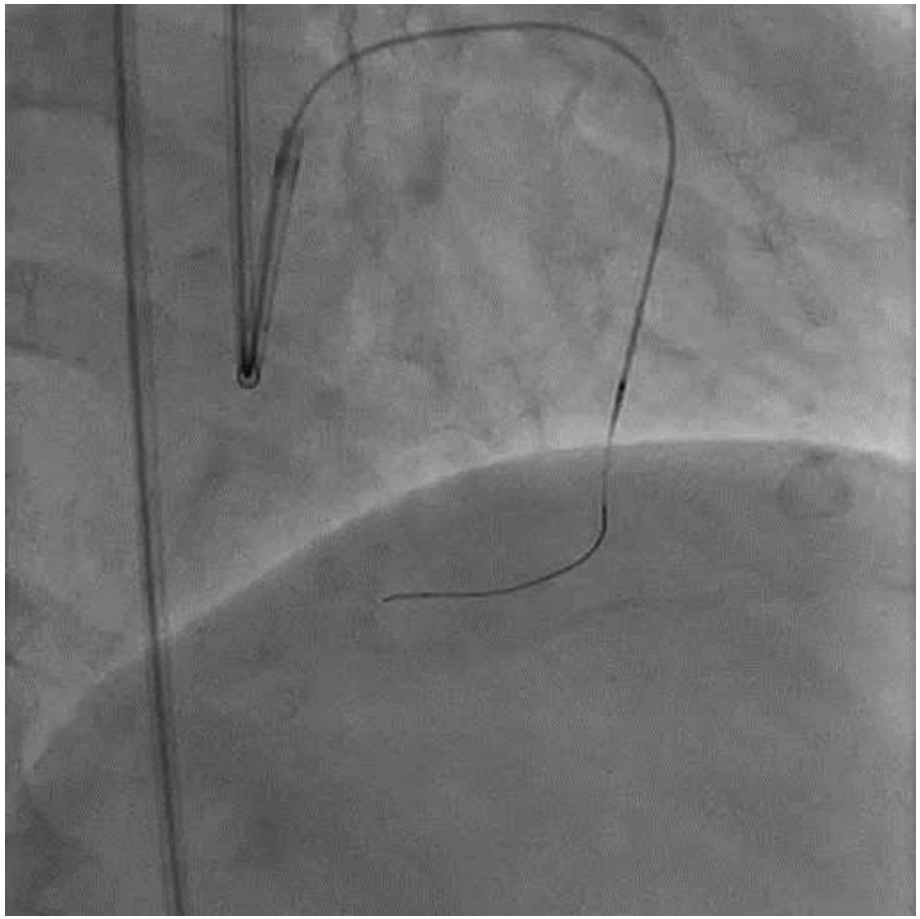


Case 4 : Perforation in sept. due to GW migration in 2008

- Coil embolization for perforation -

Retrograde channel tracking with septal collateral route

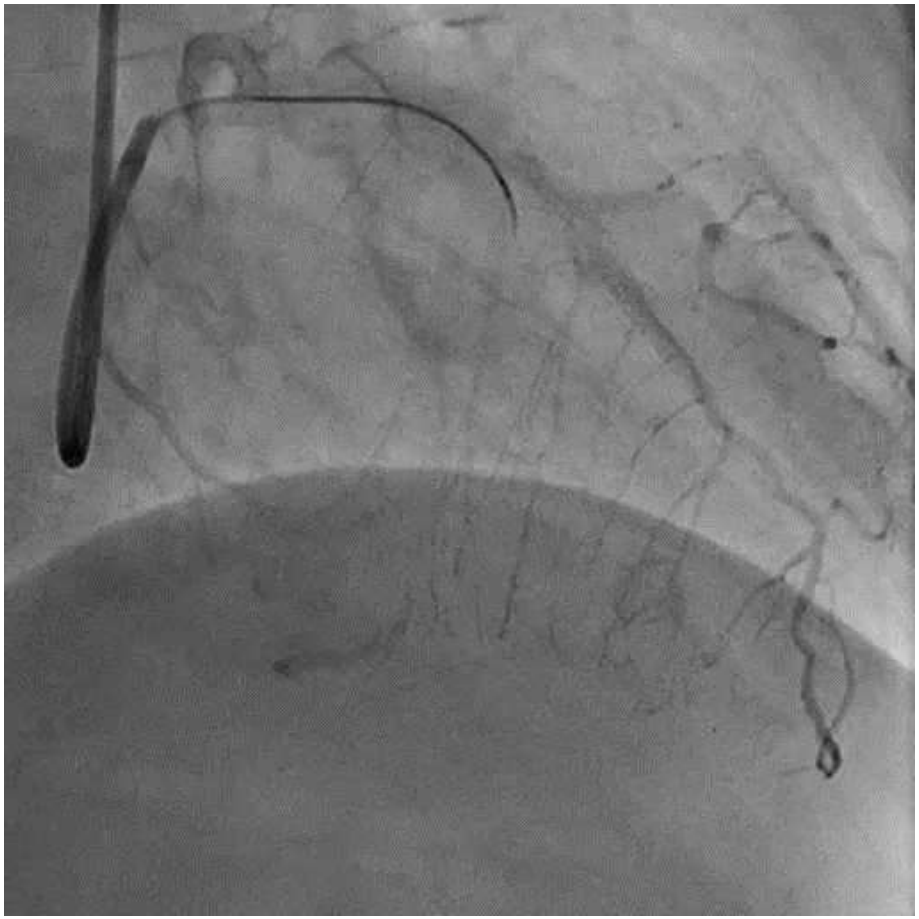




Case 4 : Perforation in sept. due to GW migration in 2008

- Coil embolization for perforation -

Roughly exploring the GW, Injure the sept.

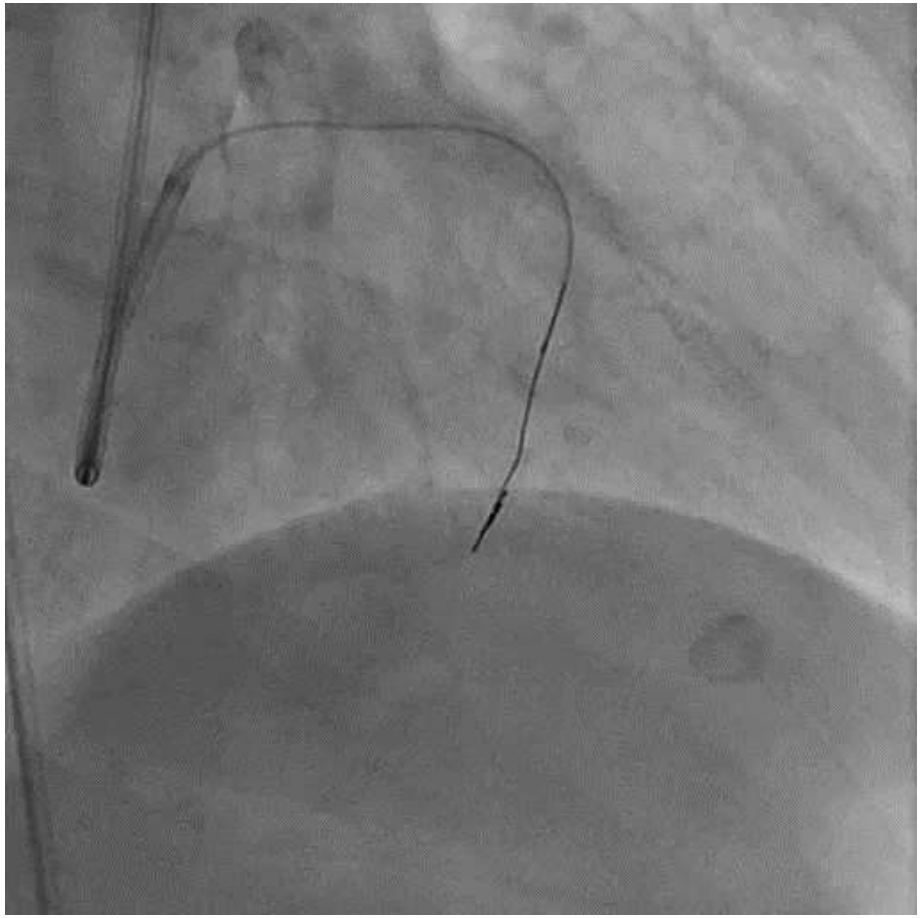


Fat tissue does not work !! Still getting bigger !!

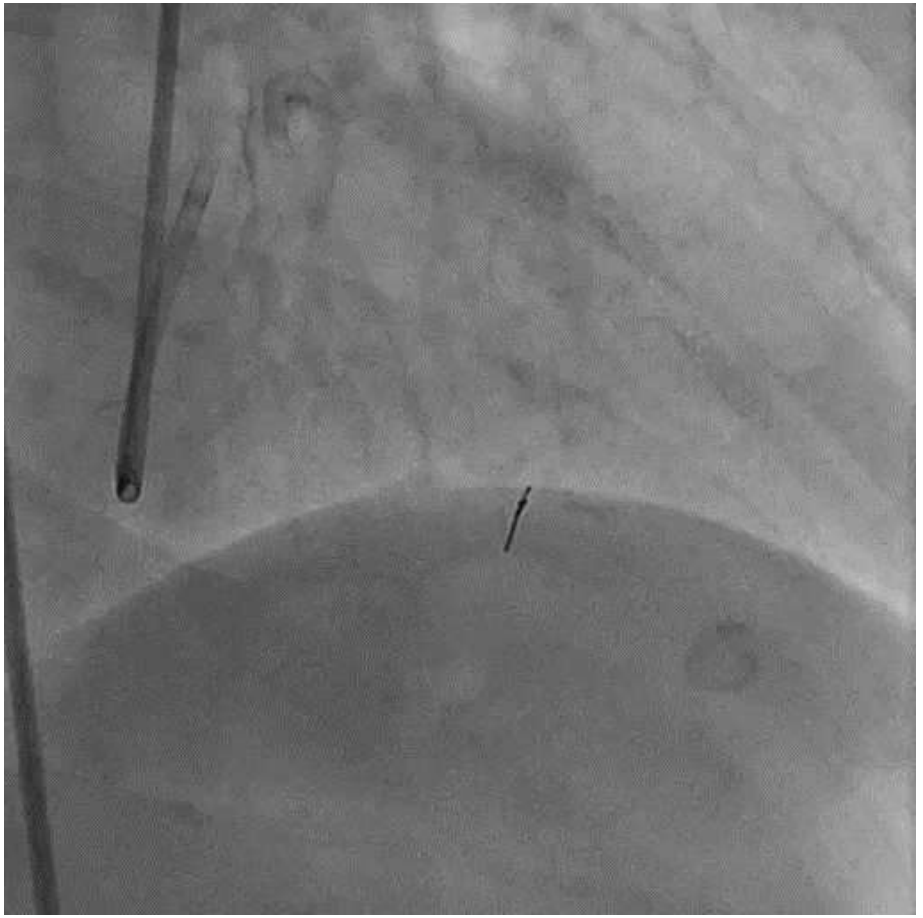
Case 4 : Perforation in sept. due to GW migration in 2008

- Coil embolization for perforation -

Coil Embolization



It WORK !!



Case 5 : GW perforation

due to it’s migration in SB

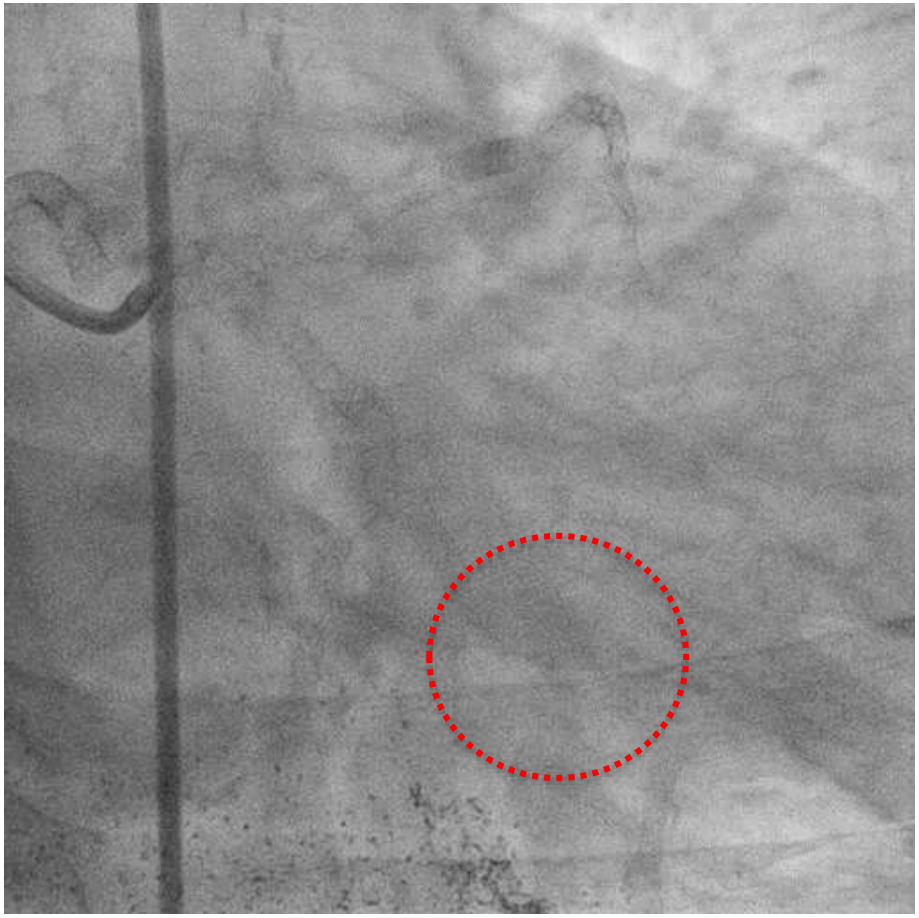
④ In case of perforation in CTO...

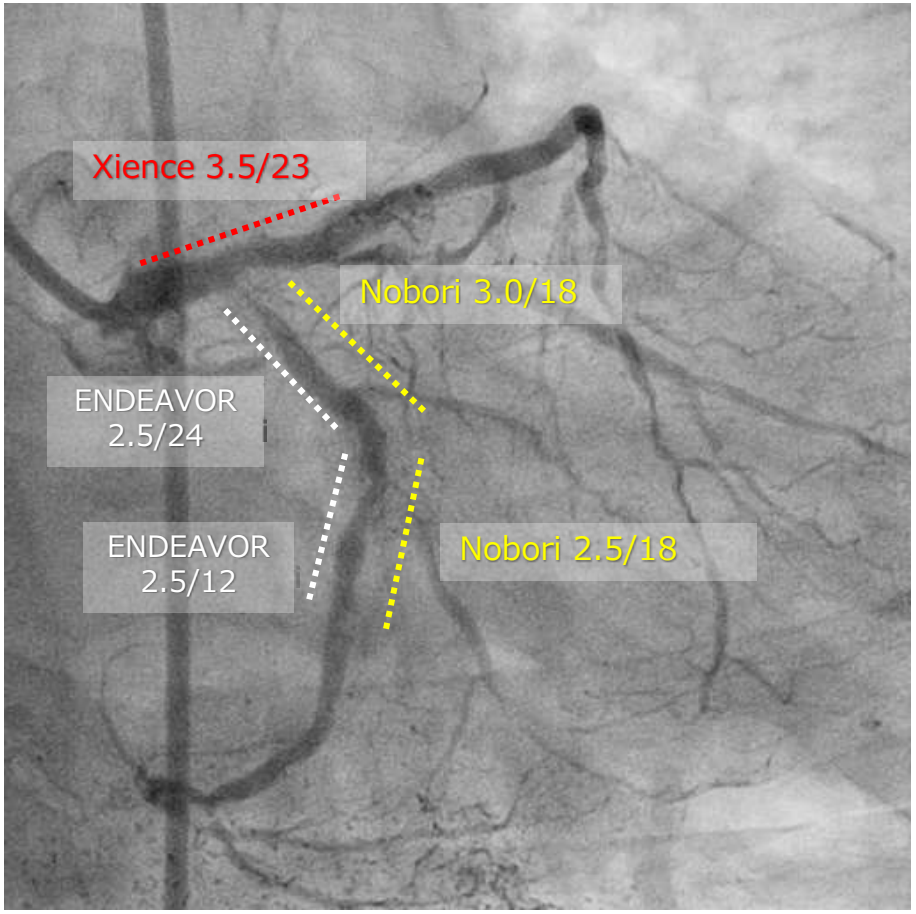
we need to do from both side...

Case 5 : Perforation in CTO of dist. LCX via GW migration in 2010

- Even after Graft Stent... Still There !! -

Restenosis in Prox.LCX and CTO of very calcified small LCX.

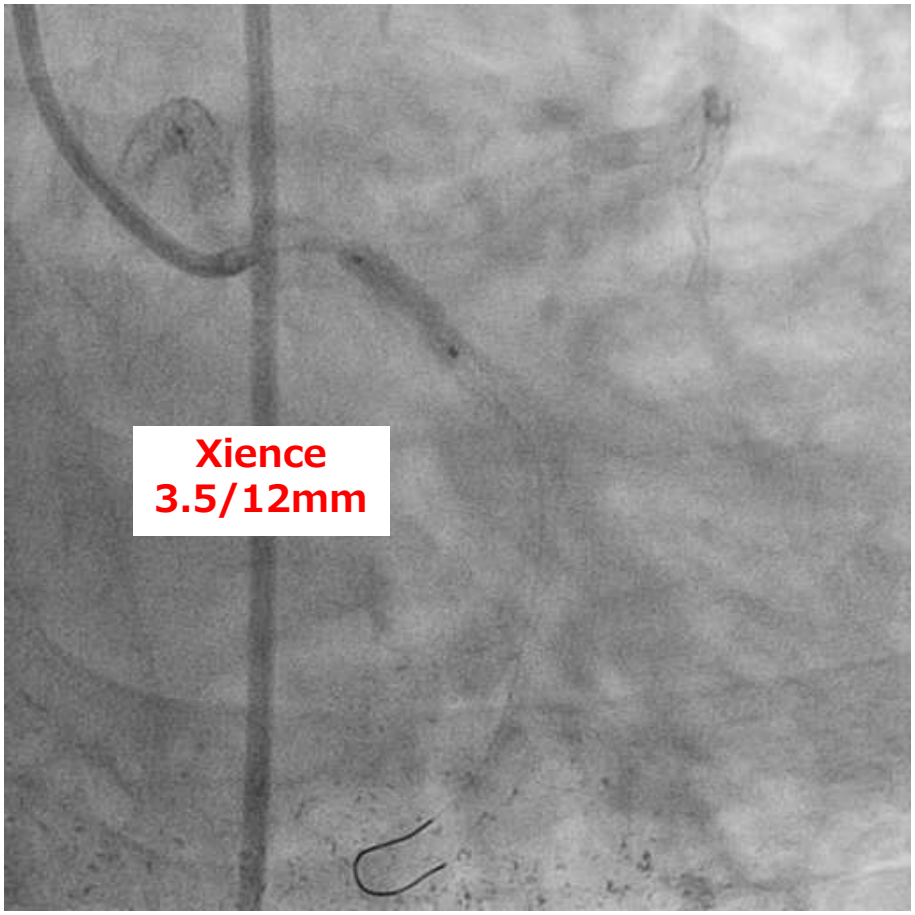




Case 5 : Perforation in CTO of dist. LCX via GW migration in 2010

- Even after Graft Stent... Still There !! -

Implant Xience Stent 3.5mm in LCX prox

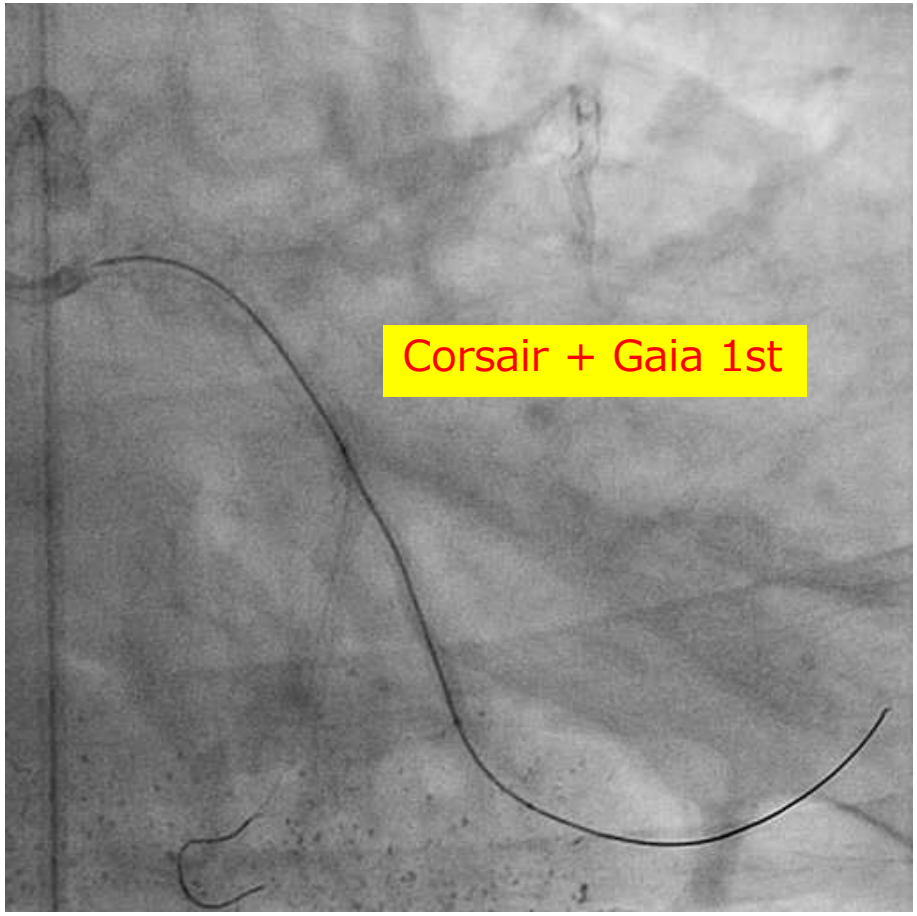


Then !!

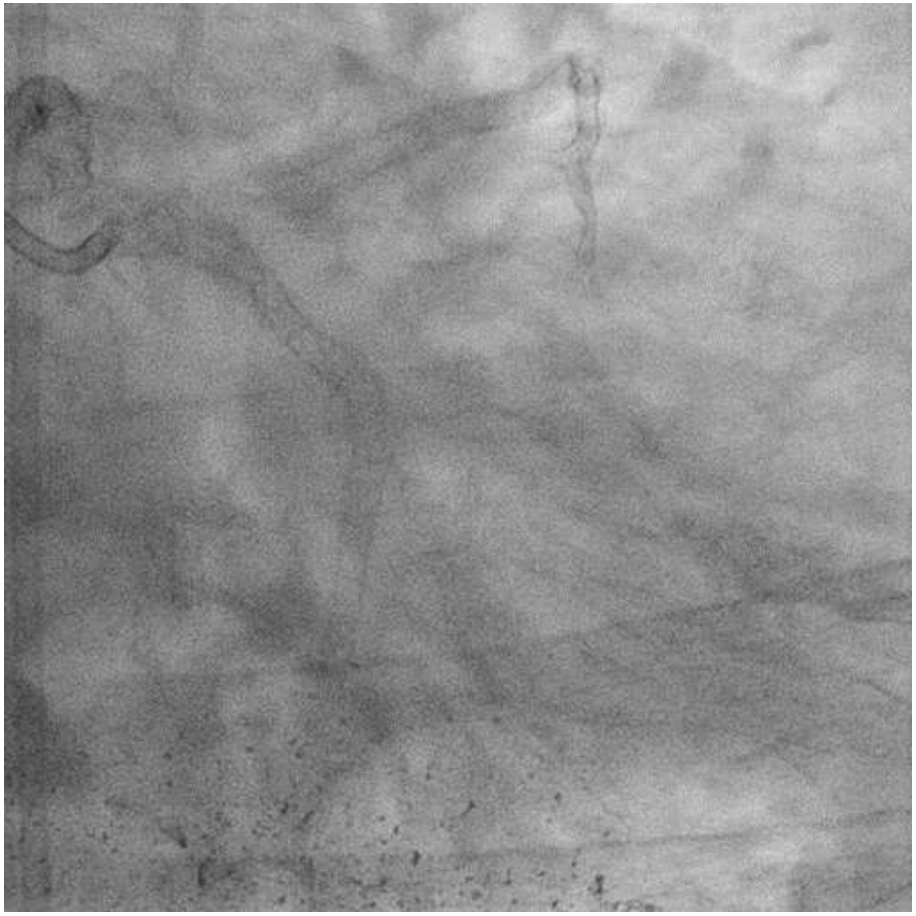
Case 5 : Perforation in CTO of dist. LCX via GW migration in 2010

- Even after Graft Stent… Still There !! -

GAIA 1st into very calcified LCX CTO,
Then we **did ballooning**



"Coronary Perforation"

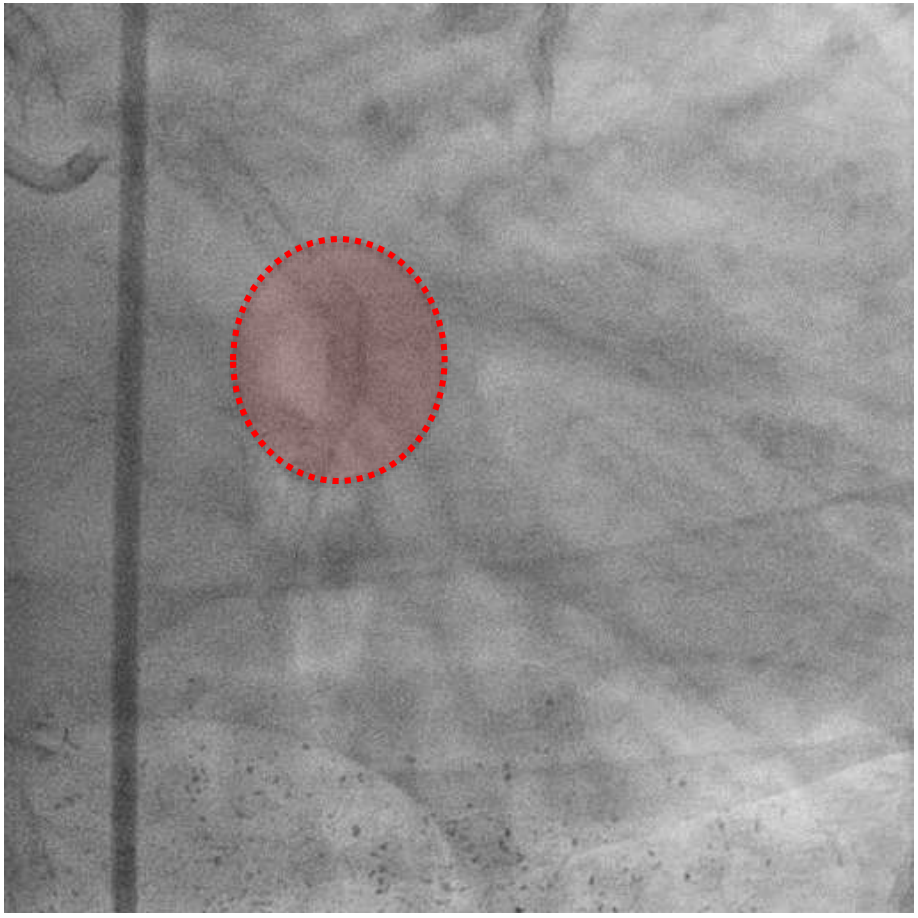


Case 5 : Perforation in CTO of dist. LCX via GW migration in 2010

Because of the collateral circulation, NO STOP BLEEDING

Embolization with fat tissue

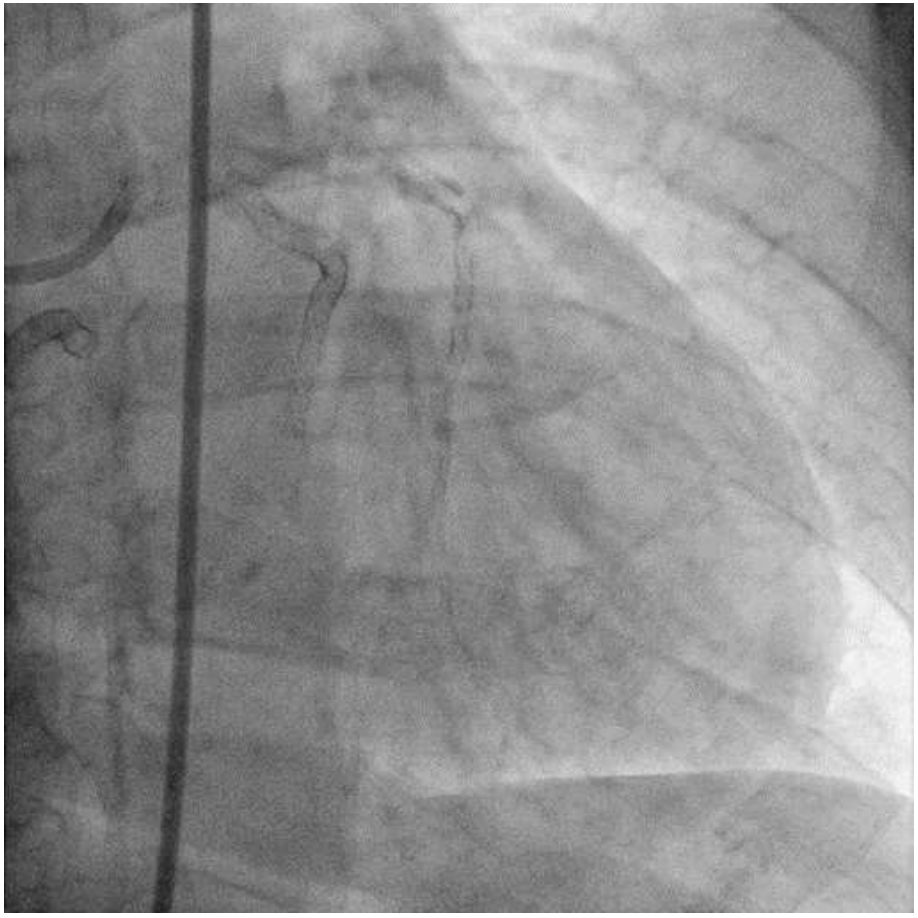
Jailing branch with GRAFTMASTER 2.5/16mm

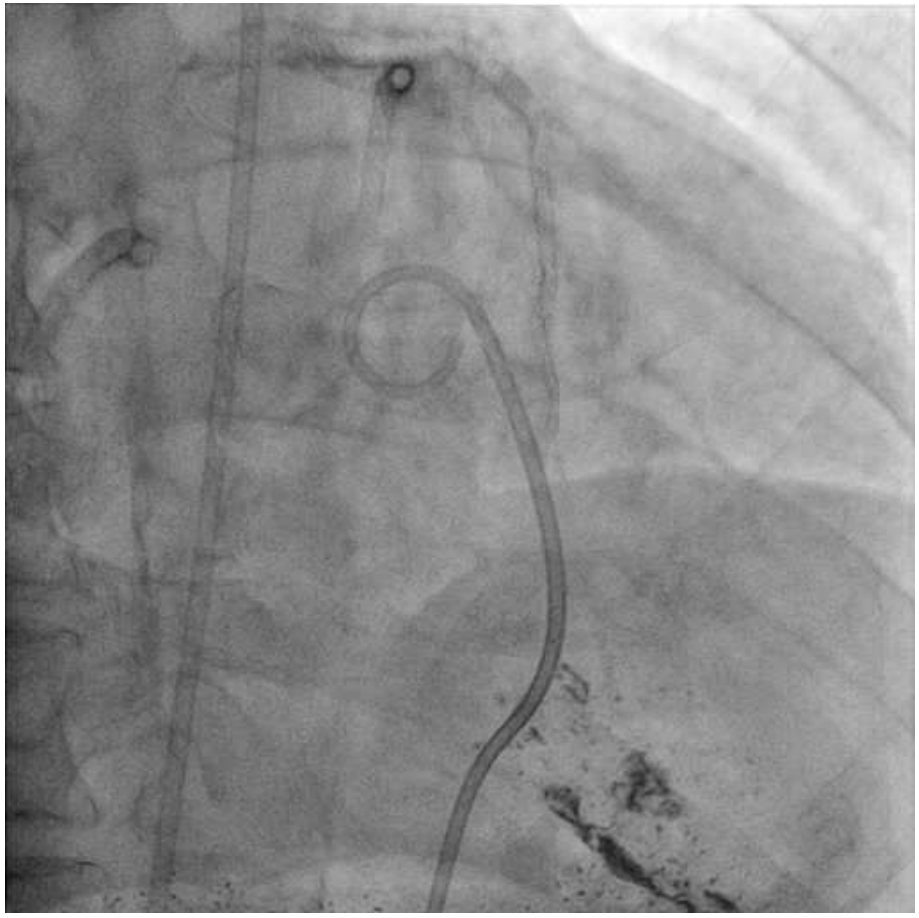


Case 5 : Perforation in CTO of dist. LCX via GW migration in 2010

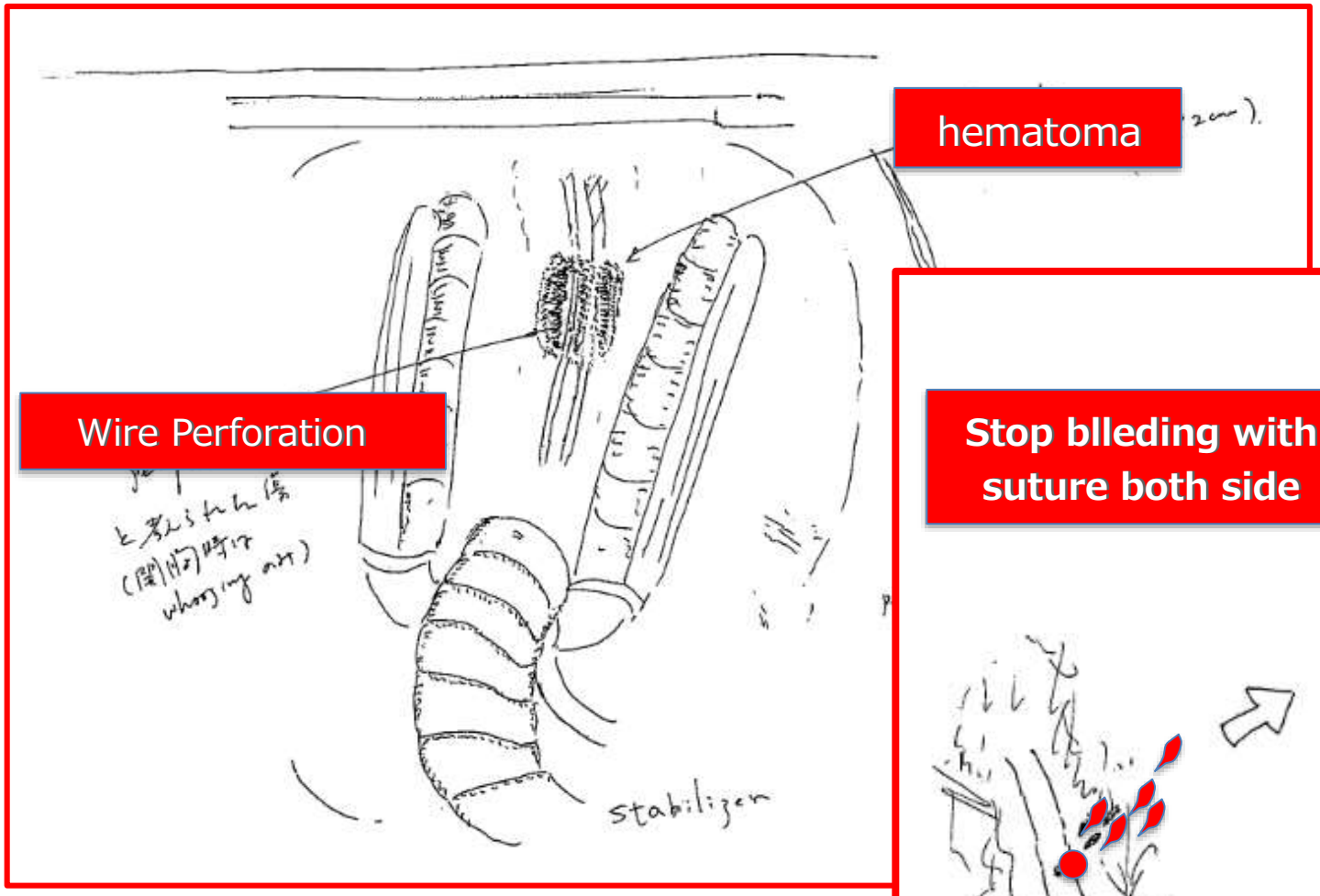
- Even after Graft Stent... Still There !! -

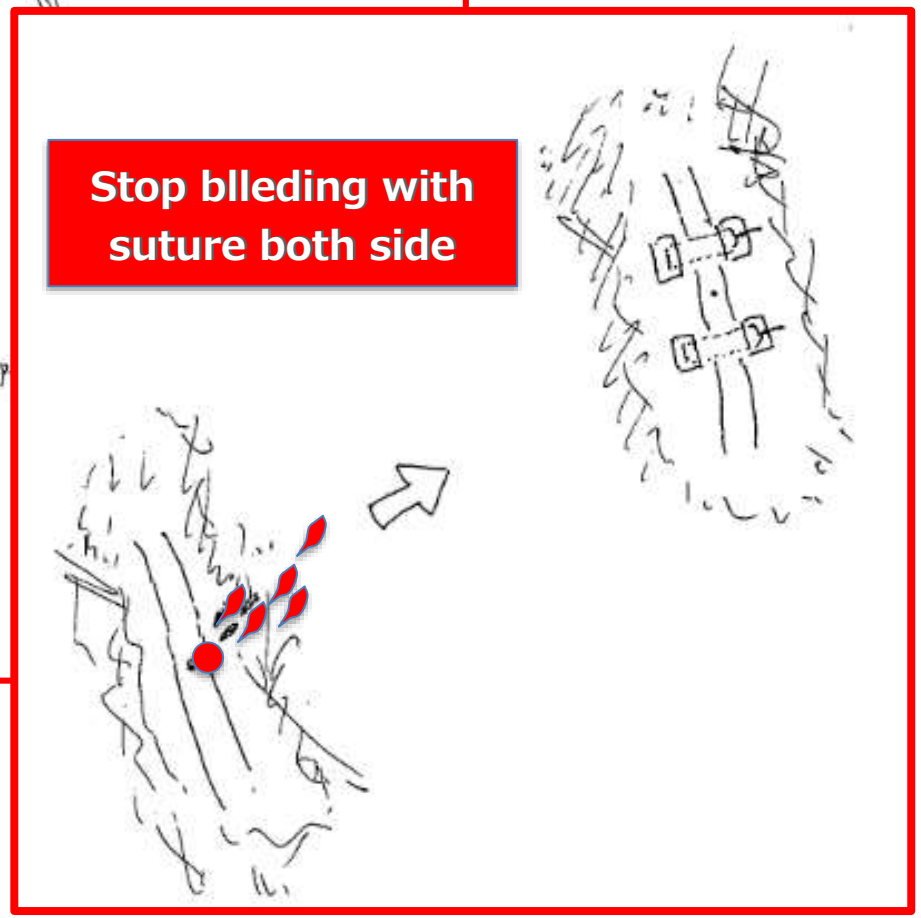
Pericadio-centesis because of the cardiac tamponade !!





We asked Cardiac surgeon to cover this situation





Case 6 : Blowout !! perforation

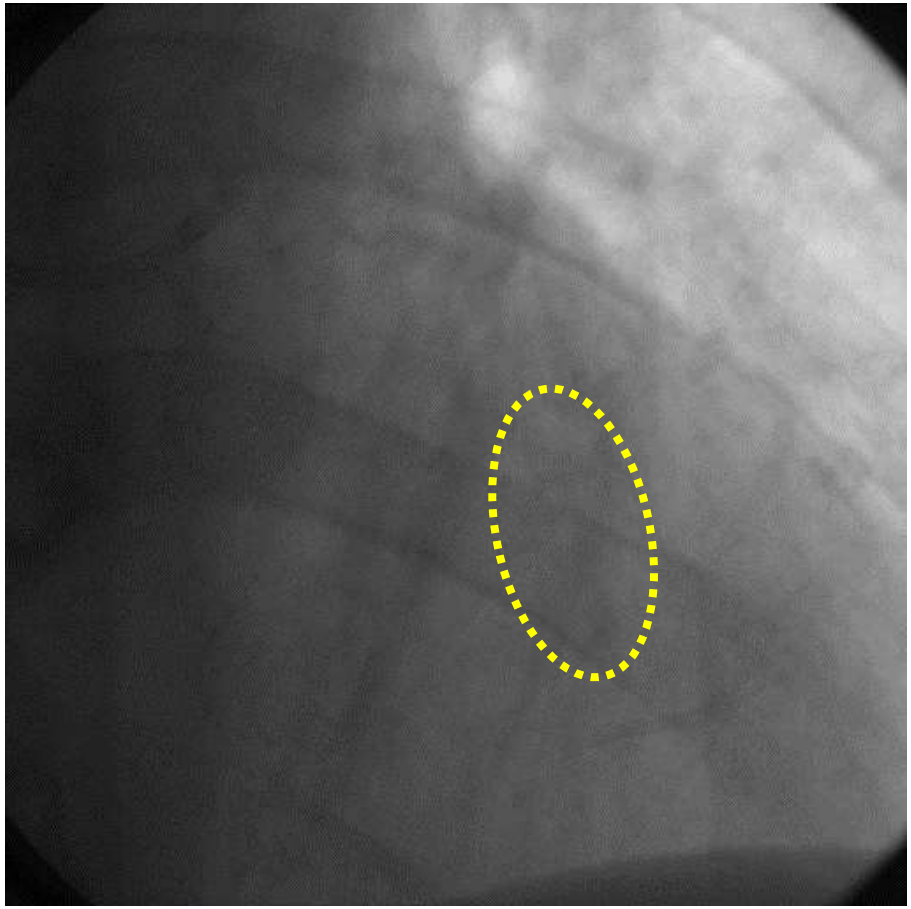
due to ...

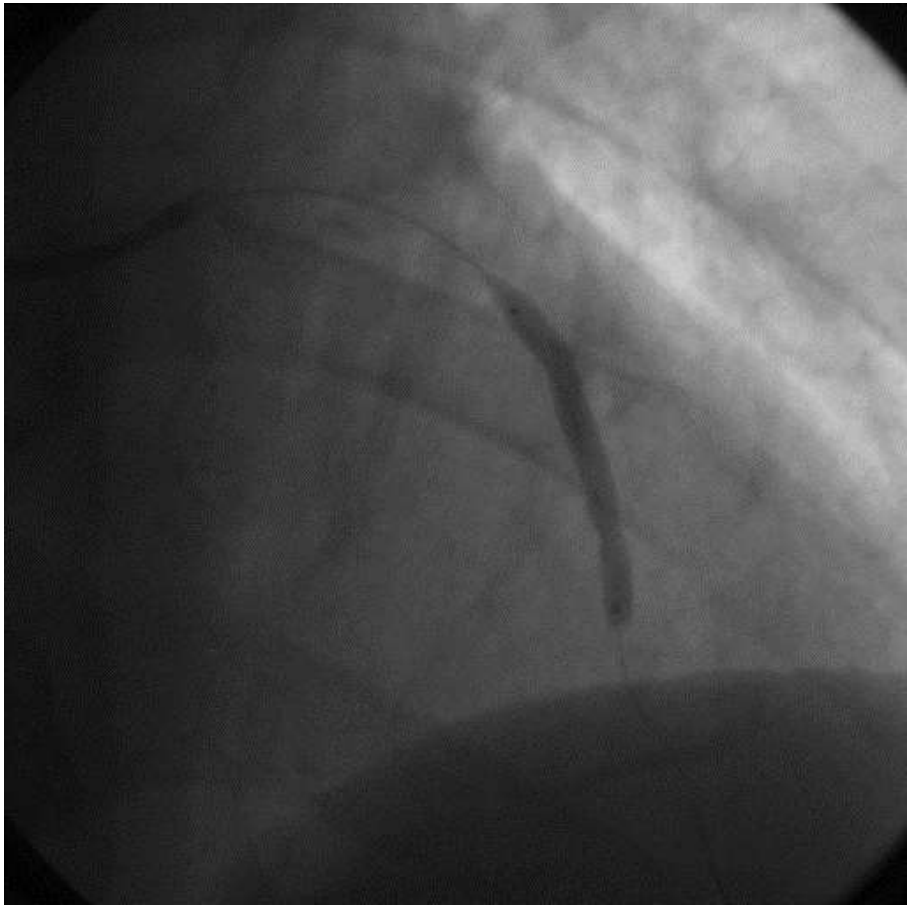
① Graft stent

Case 6 : Perforation in LAD after direct stenting in 2002

- Ellis classification Type Ⅲ -

Direct stenting in LAD mid with 3.5mm DES

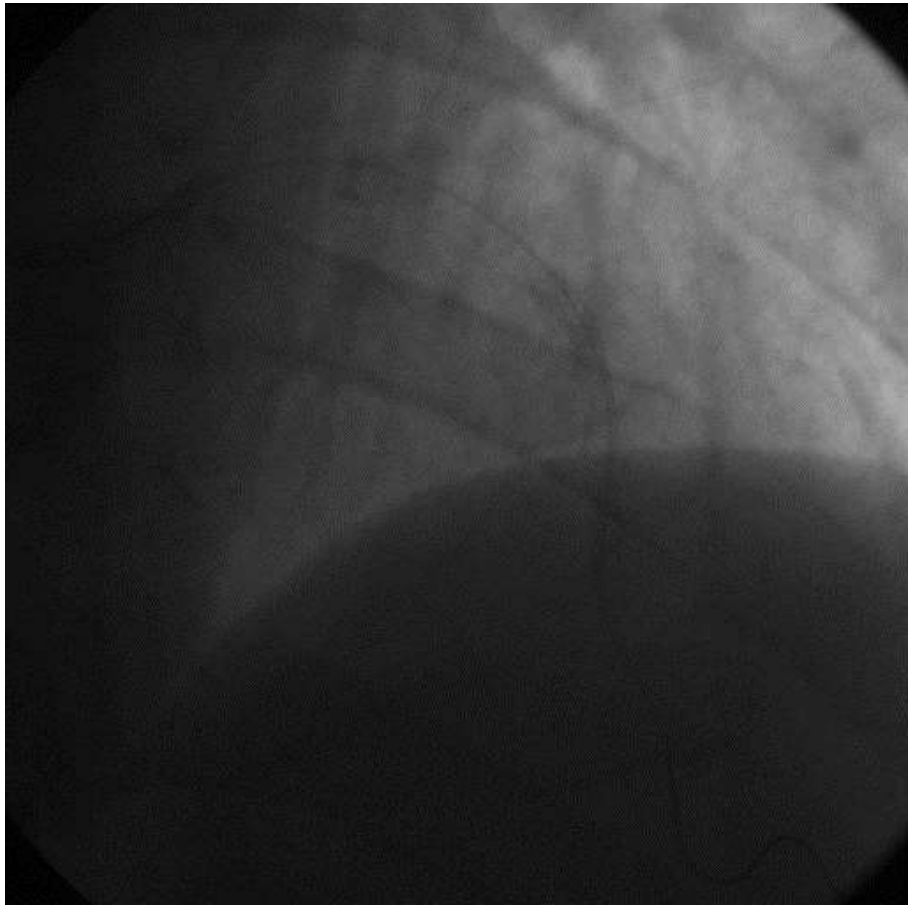




Case 6 : Perforation in LAD after direct stenting in 2002

- Ellis classification Type Ⅲ -

Blow out Perforation !!



What should we do NEXT ???

1. Immediately, collapse the patient
   Chest pain, BP drop !!, Fainting

2. Ballooning the site of perforation
   Stop bleeding with same balloon !!

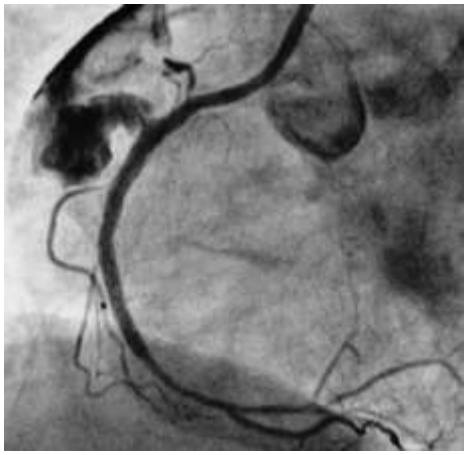
3. Pericardiocentesis
   Pericardial drainage
   Blood Suction and place suction bag

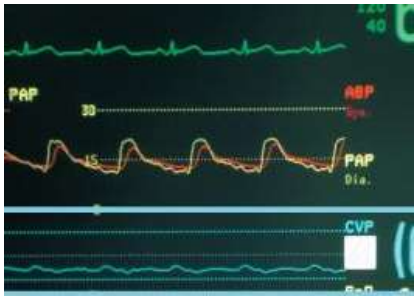
4. Change the perfusion balloon
   Avoid ischemia !!

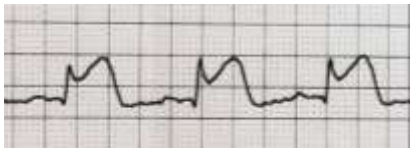
3 Important Theory

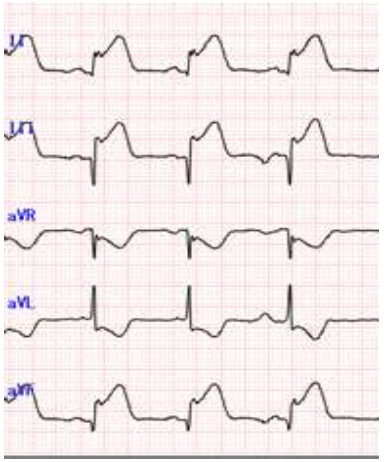
- In case of emergency -

1. How much time I have left
2. Grasp the situation what' going on
3. What should I do now, immediately ?









3 Important Theory

- In case of emergency -

1. How much time I have left

   ① Within 3~5min. Otherwise, just collapse the patient

2. Grasp the situation what' going on

   ① Coronary perforation Ellis type Ⅲ

   ② BP ↓ loss of consciousness !!

   ③ Cardiac Tamponade → Level of need Pericardiocentesis

3. What should I do now, immediately

   ① Stop bleeding with Balloon (perfusion balloon)

   ② Pericardiocentesis, Pericardial drainage (500cc blood)

   ③ Think !! Next option !!

3 Important Theory

- In case of emergency -

Condition...

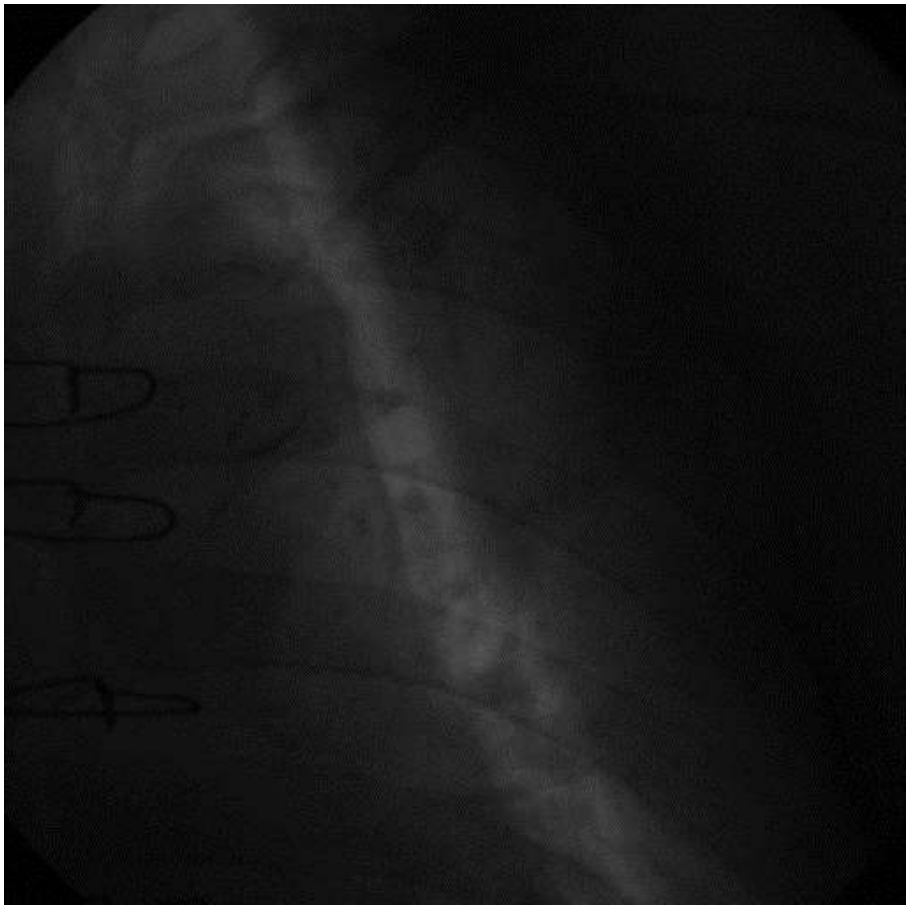
1. 17 years ago : No Graft stent
2. Already 500cc bleeding in the beaker
3. Had a best cardiac surgeon in my whole life

Ask cardiac surgeon !!

Case 6 : Perforation in LAD after direct stenting in 2002

- Ellis classification Type Ⅲ -

After CABG !!



CABG:
On-lay patch plasty
(total operation time 2.5hr.)

procedure time for controlling
cardia tamponade : 2.5hr.

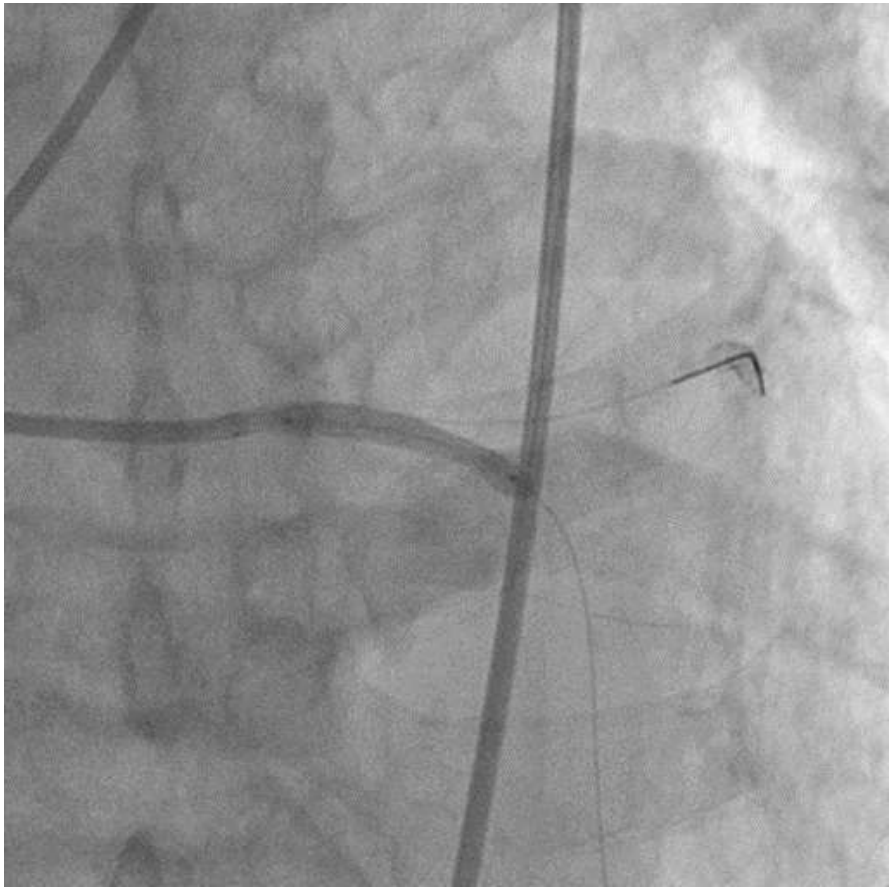
Patient was saved !!
with good clinical course !!

Case 7 : Perforation in LAD after direct stenting in 2006

- Ellis classification Type Ⅲ -

Pre

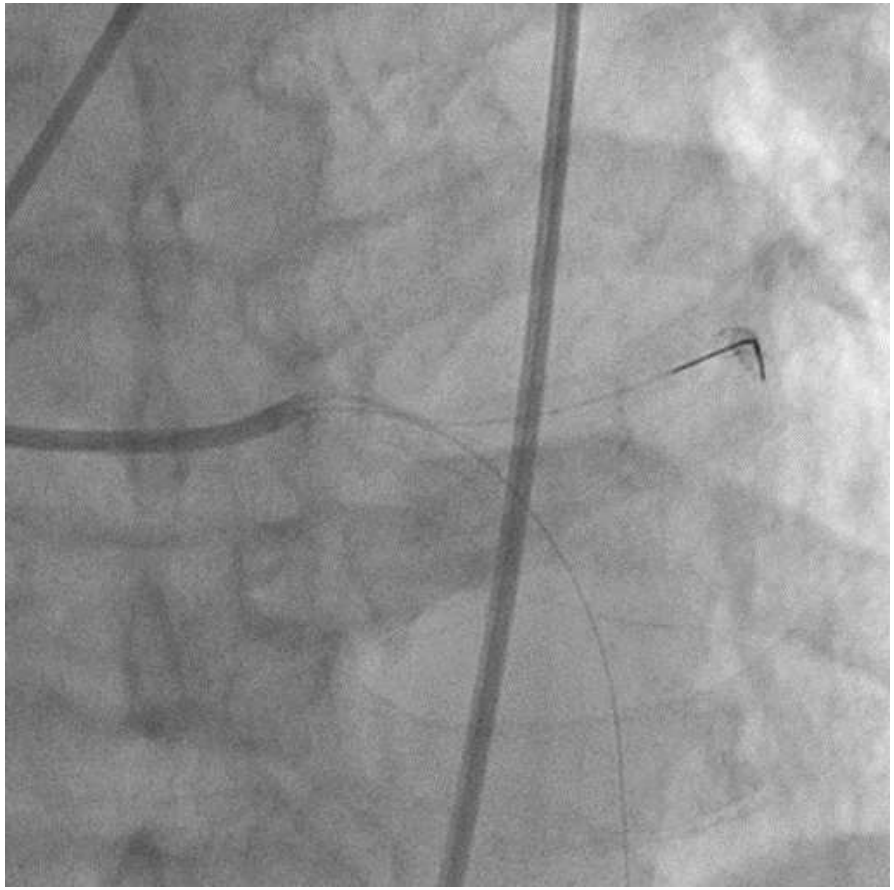
Direct stenting 3.5mm DES in LAD



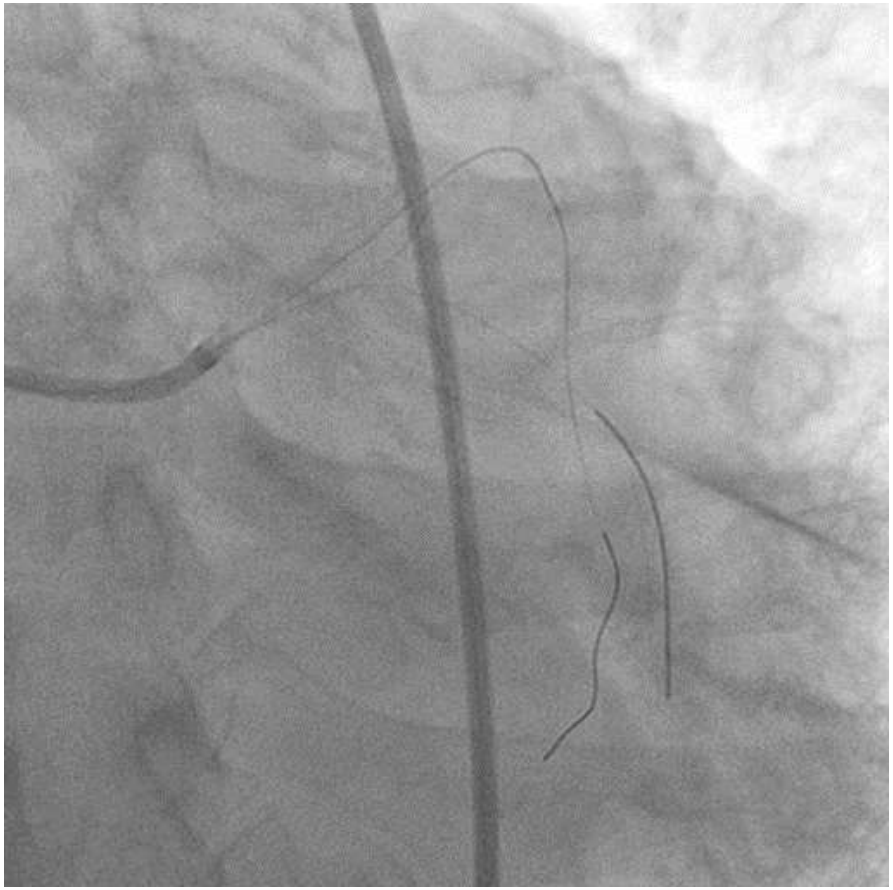
Case 7 : Perforation in LAD after direct stenting in 2008

- Ellis classification Type Ⅲ -

Blow out type perforation



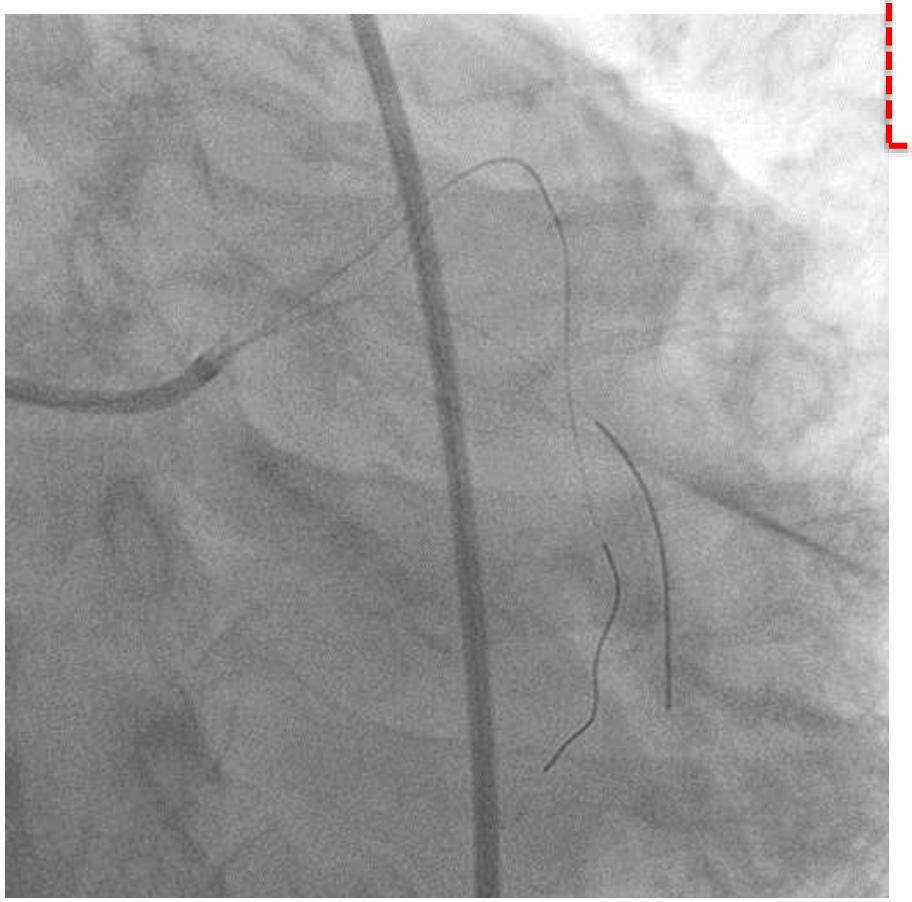
5 seconds, Next, Check AP caudal view



Case 7 : Perforation in LAD after direct stenting in 2008

- Ellis classification Type Ⅲ -

Why ?? Checking AP caudal view...



1. you are the only person can save the patient !!
2. First Action after happening, decide Pt's life.

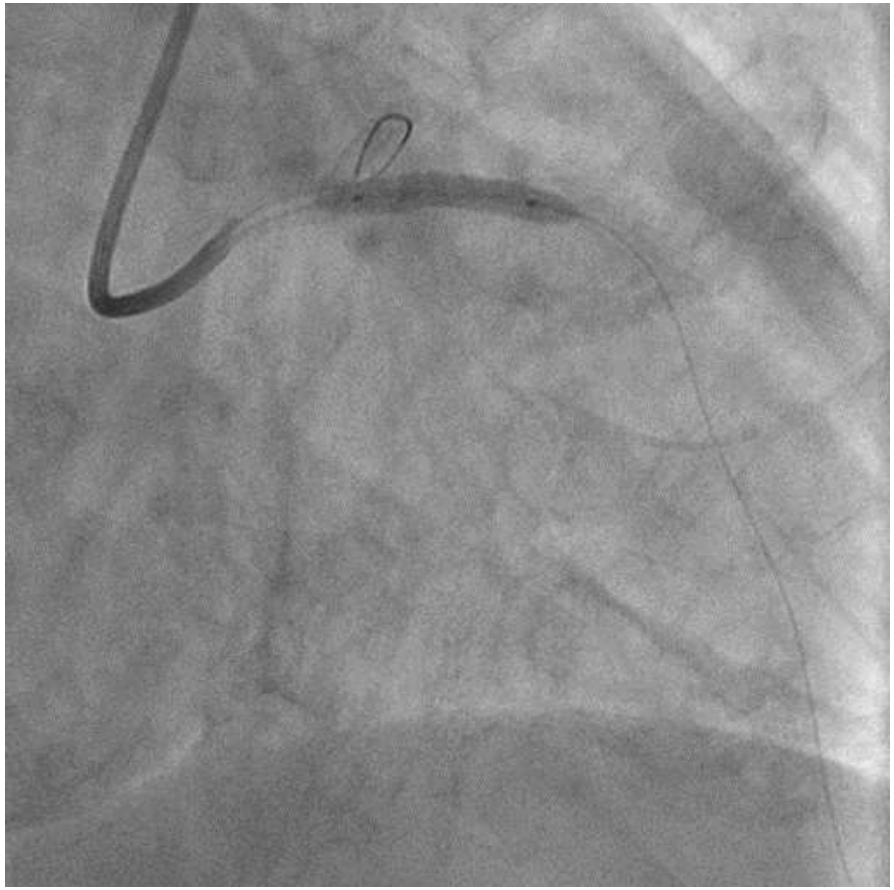
Within 5secinds

3. Check AP caudal to confirm the perforation site involving LCX or not ???
4. If yes or not is related changing strategy.
5. This case had a space to implant Graft. S
6. After sealing out, seemed to be nothing happen , Pts went general word

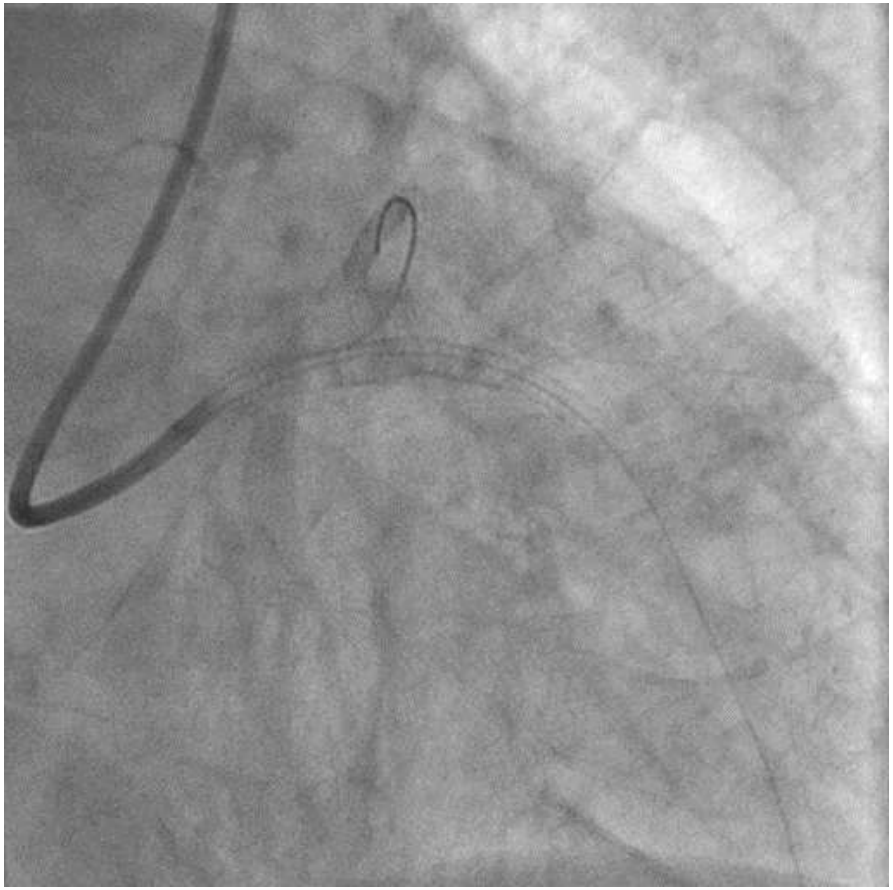
Case 7 : Perforation in LAD after direct stenting in 2008

- Ellis classification Type Ⅲ -

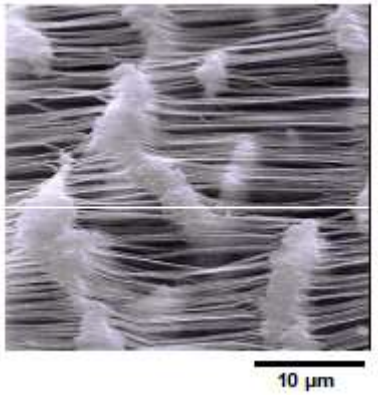
Graft stent implantation



Check AP caudal view



About Graft Stent



double layer 2 stent
in PTFE membrane !!

1. Very reliable, but less trackability
2. Must and Must POST HP Dilatation
3. be able to in the Extension !!
4. Very improved restenosis rate in current version !!
5. Very precise placement is very very essential !!

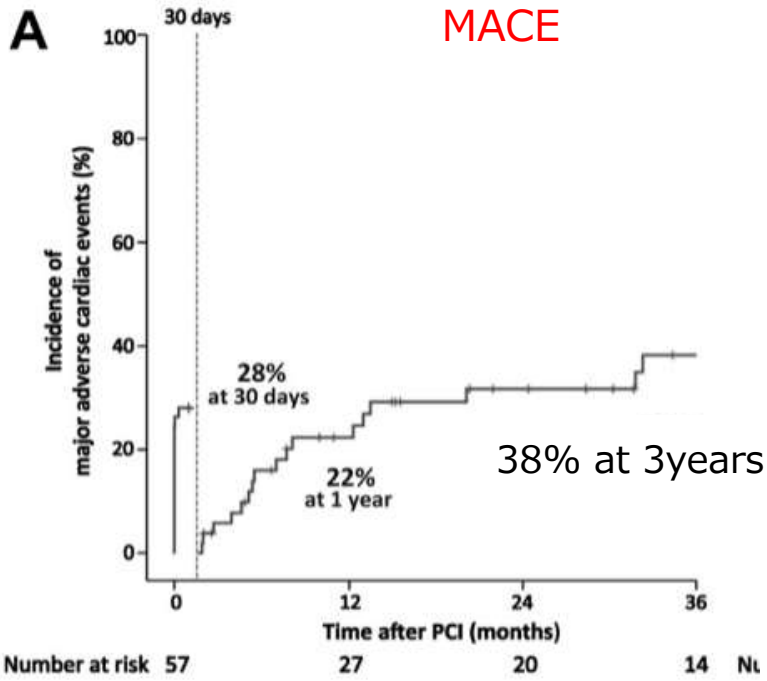
Compatibility of GRAFTMASTER (2.8 mm, 3.5 mm) for various support catheters

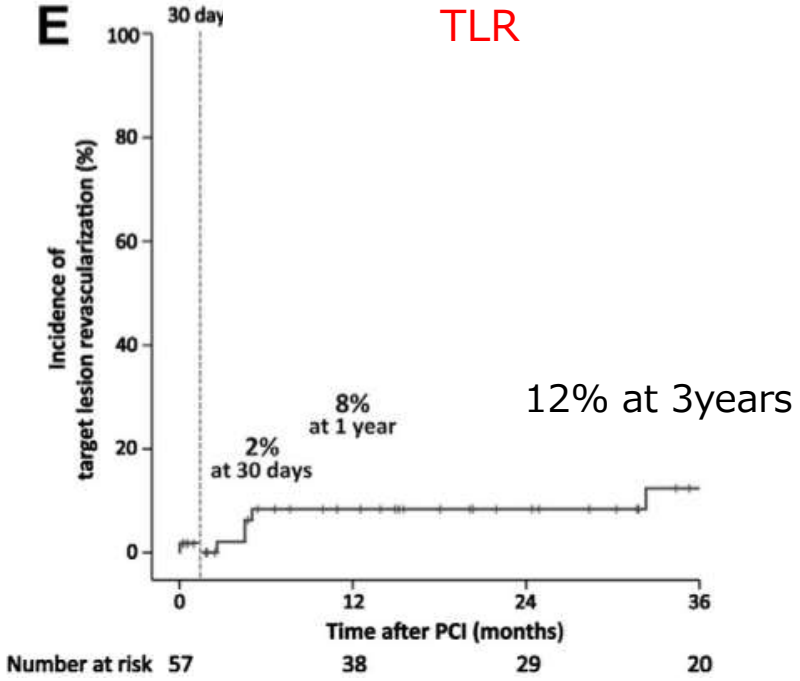
Support catheter	Compatibility
GuideLiner 5.5 Fr	×
GuideLiner 6.0 Fr	△
GuideLiner 7.0 Fr	○
Guide Zilla 6.0 Fr	△
Heartraill　4.0 Fr ST01	×
Heartraill　5.0 Fr ST01	○
○＝**Easy**　△＝**Possible**　×＝**Impossible** GRAFTMASTER (Abbott Vascular, Santa Clara, CA)	
Guide Liner (Vascular Solutions, Minneapolis, MN) Guide Zilla (Boston Scientific, Marlborough, MA) Heartrail (Terumo, Tokyo)	

Short-Term and Long-Term Outcomes After Polytetrafluoroethylene-Covered Stent Implantation for the Treatment of Coronary Perforation

Hiroyoshi Kawamoto M.D. Sunao Nakamura M.D. et al Am J Cardiol. 2015 Dec 15

Among 19270 PCI patients, Need 57 Graft stent

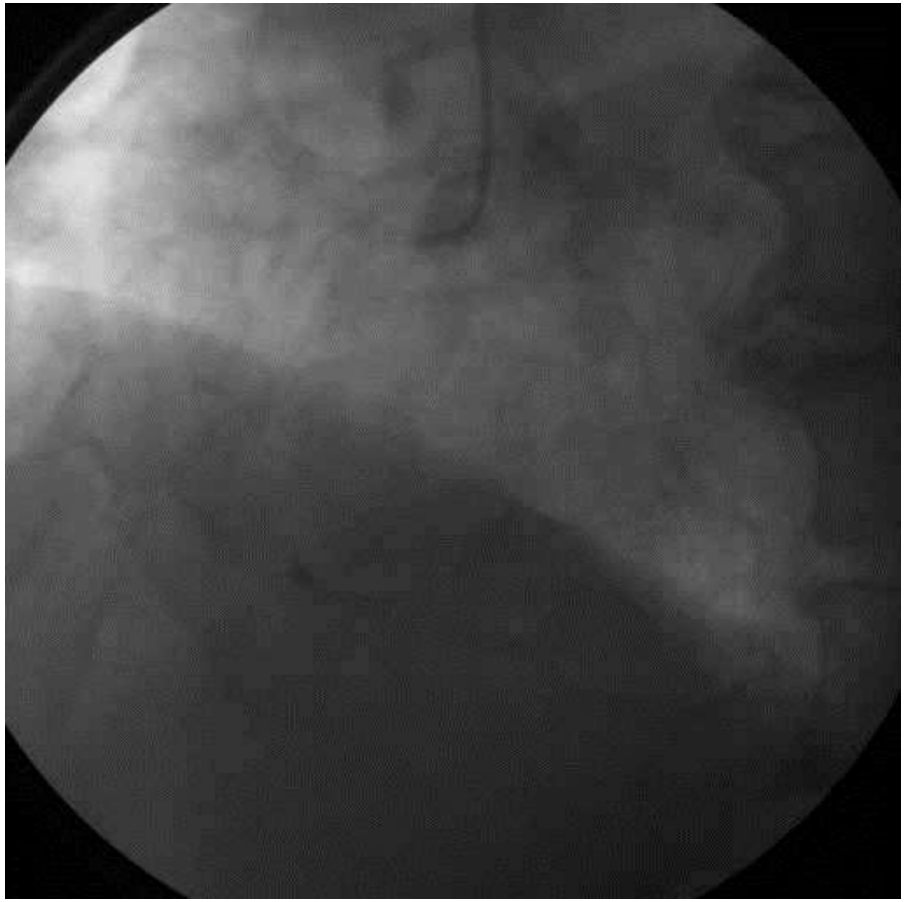


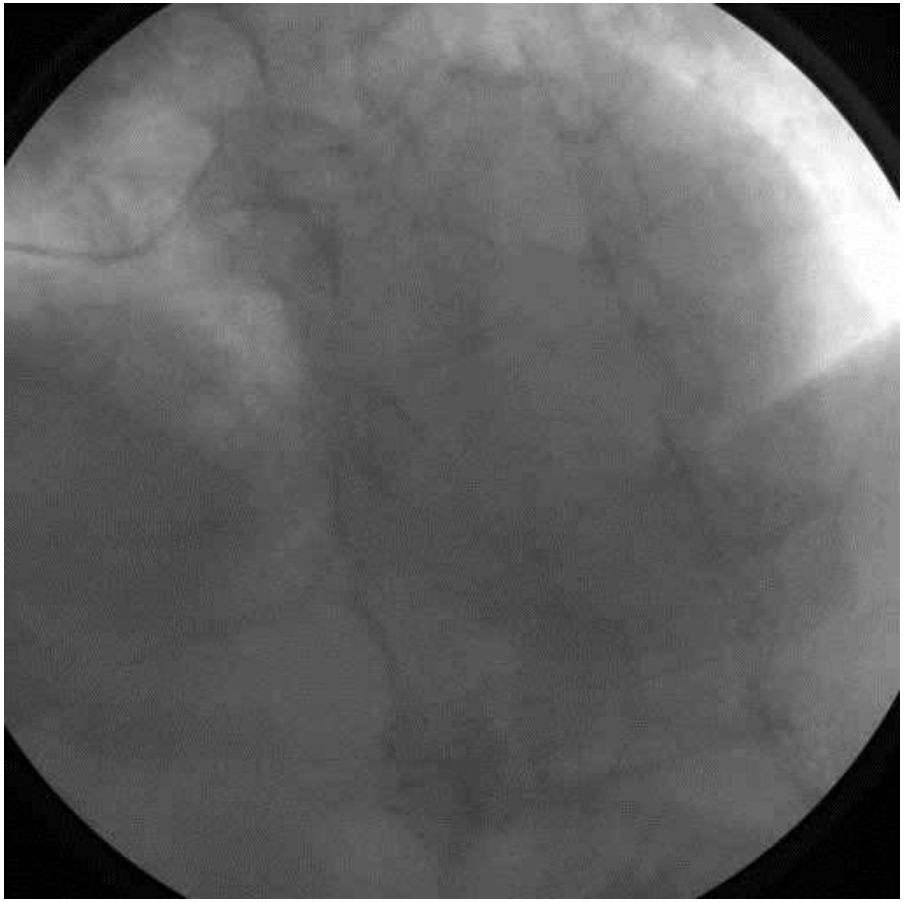


Case 8 : Perforation in RCA during CTO PCI in 2006

- Ellis classification Type Ⅲ -

In Malaysia 2006: CTO work shop

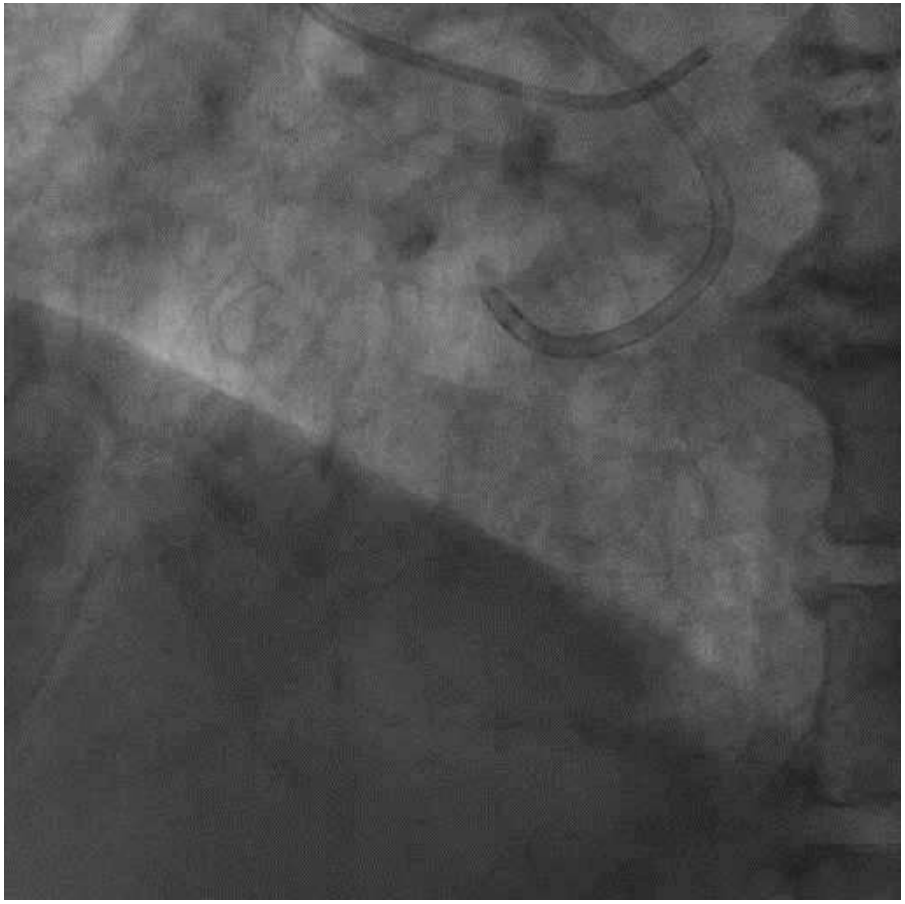


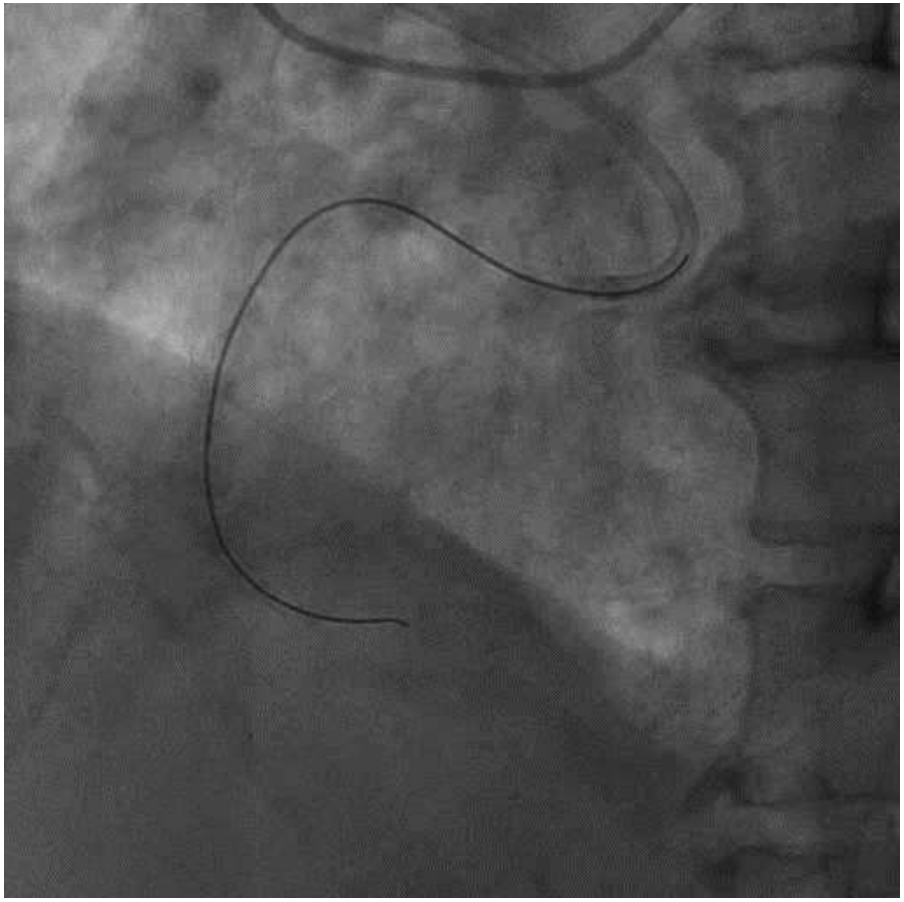


Case 8 : Perforation in RCA during CTO PCI in 2006

- Ellis classification Type Ⅲ -

No Cosair, No GAIA, No Retrograde Approach : GW＝miracle 6g

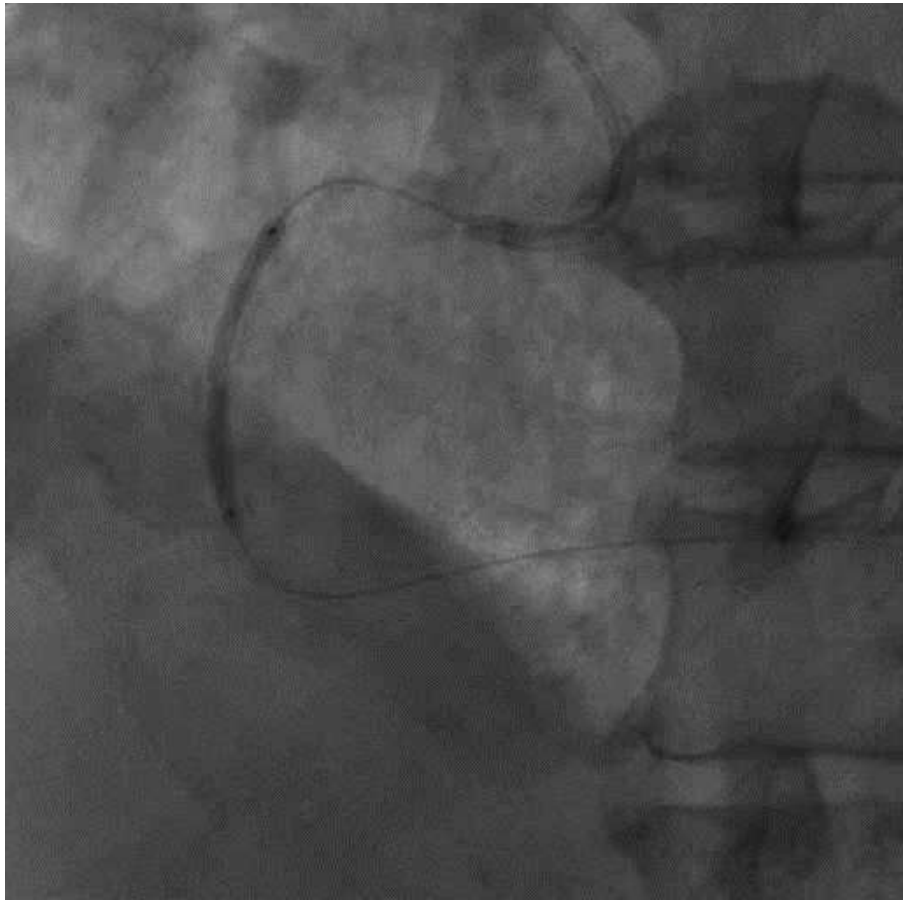


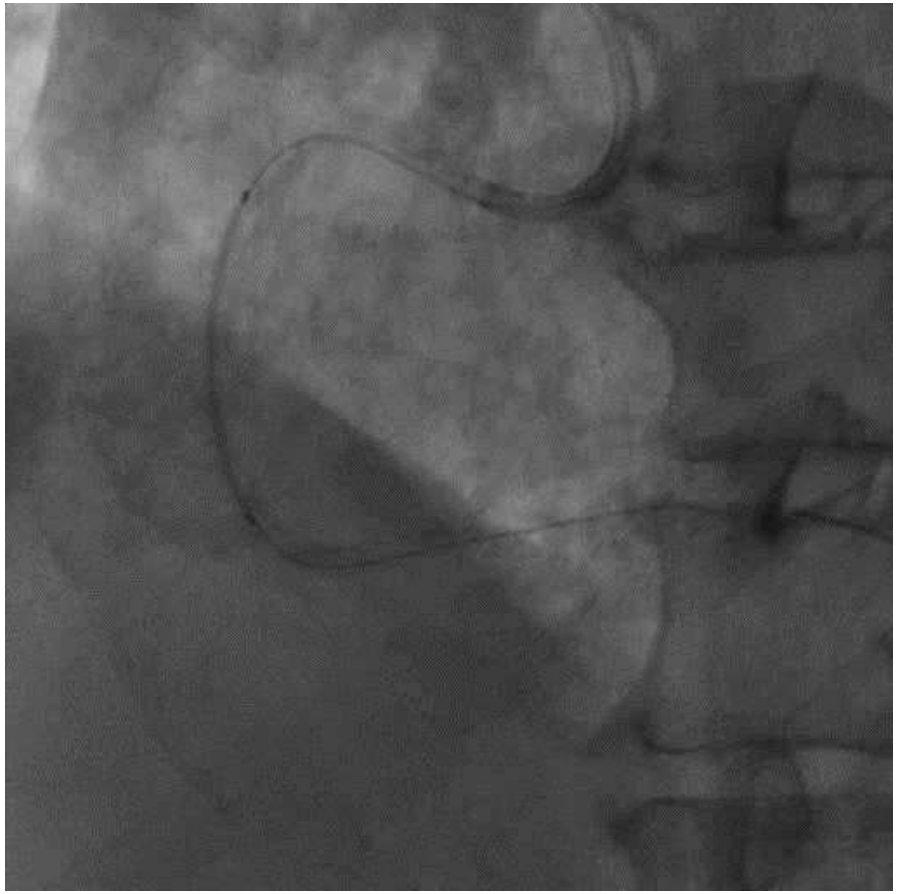


Case 8 : Perforation in RCA during CTO PCI in 2006

- Ellis classification Type Ⅲ -

Ballooning and stenting (3.5mm DES long without IVUS !!





Case 8 : Perforation in RCA during CTO PCI in 2006

- Ellis classification Type Ⅲ -

Massive perforation in mid RCA

Blow out perforation !!
Due to mismatch size stenting ??

Vital collapse !!
immediately, went into cardiac tamponade

At first, stop bleeding with Stent Balloon
Then cardiaccentesis and drainage !!

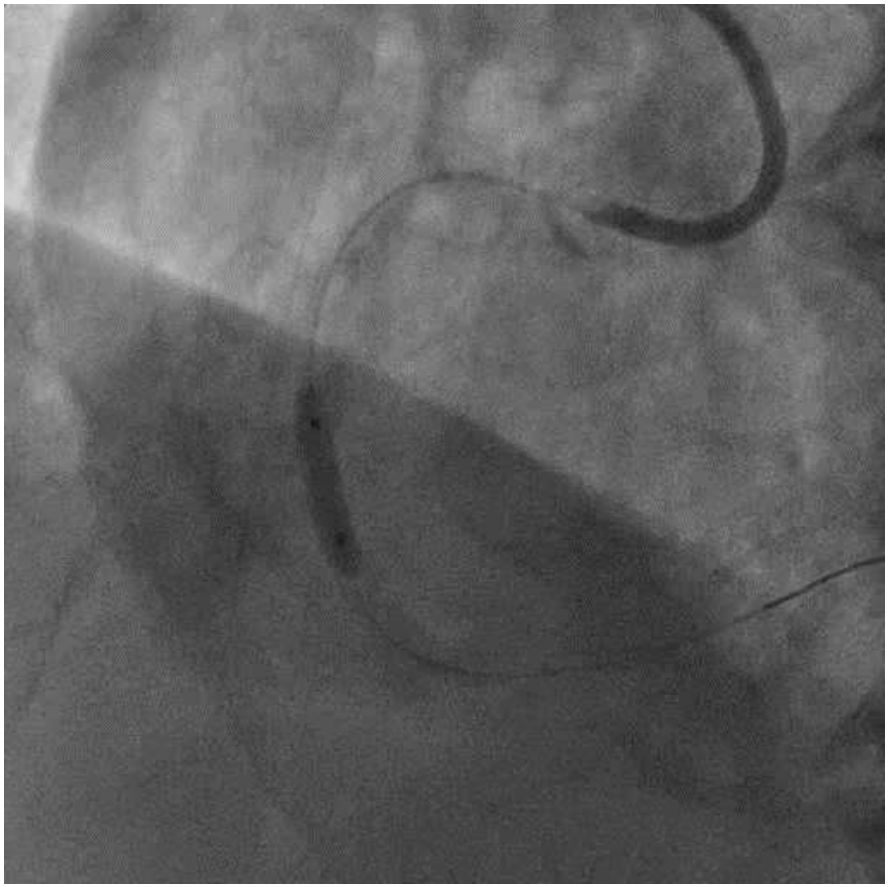
Bleeding from this 500cc

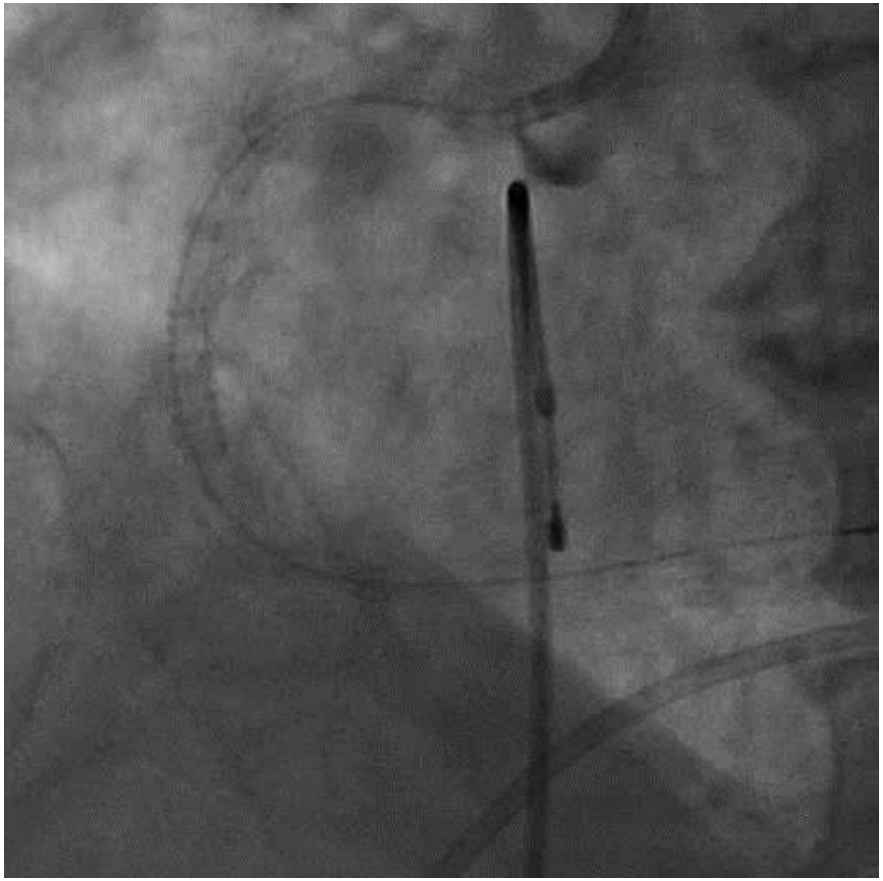
Graft stenting in stented site ,
Be careful of post dilatation
Should not leave bleeding !!

Case 8 : Perforation in RCA during CTO PCI in 2006

- Ellis classification Type Ⅲ -

With general control of pt's condition, with very much enough post dalatation, finishing !!





Most Important Theory

- In case of emergency -

1. How much time I have left
2. Grasp the situation what' going on
3. What should I do now, immediately ?