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Bifurcation PCI

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EXPERT CONSENSUS

Percutaneous coronary intervention for bifurcation coronary lesions using optimised angiographic guidance: the 18th consensus document from the European Bifurcation Club

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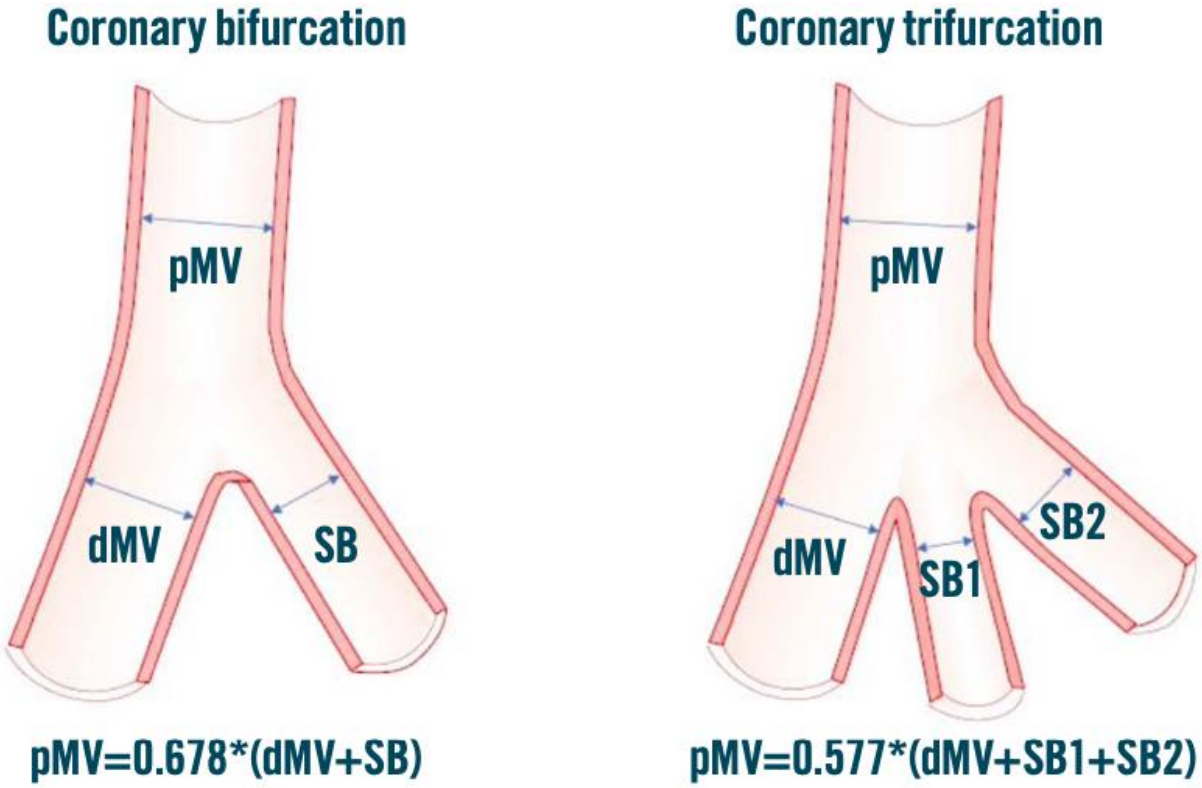
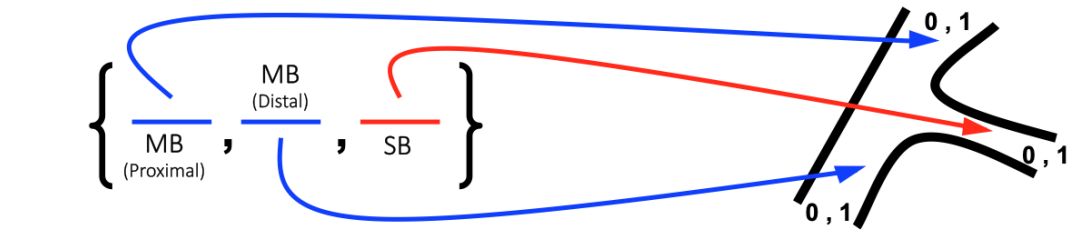
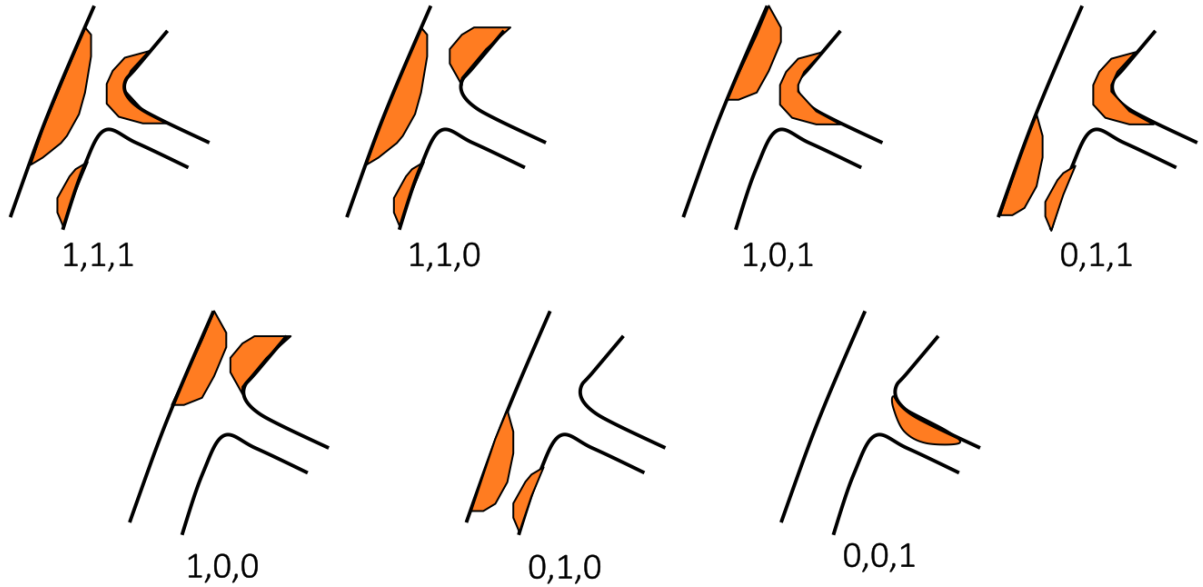
Key rules for coronary bifurcations



Finet's law formula

Modified Medina classification





How to approach a bifurcation PCI in the absence of intracoronary imaging

- Attempting to simplify and standardise the procedure as much as possible and limiting the number of implanted stents by using a stepwise provisional strategy remains the recommended strategy for the majority of true LM and non-LM CBLs.

- This enduring recommendation of the EBC has recently been further supported by the results of the EBC TWO and EBC MAIN randomised trials.
- These studies have proven that a second stent was needed in only 20% of the cases randomised to a stepwise provisional approach and that fewer revascularisations occurred if the amount of metal was kept to a minimum.

- When SB stent placement is required after main vessel stenting, use of T-stenting, T and small protrusion (TAP) or culottes are the possible technical options.

Key principles of bifurcation PCI promoted by the European Bifurcation Club

Essential target	Description
Keep the procedure simple and safe	- Choose a provisional stepwise stenting strategy
Respect the original bifurcation anatomy and physiology and aim to reproduce it	- Reconstruct the bifurcation anatomy with respect to the Finet, Murray and Huo-Kassab laws
Limit the number of stents	- Use a stepwise provisional strategy when the use of two stents is anticipated - Implant the first stent reversely from the SB to main branch when the SB is severely diseased - Use kissing balloons (opens the SB and centres the carina) - Implant a second stent only if needed (as T, TAP or culotte)

Essential target	Description
Do not stent the SB by default	- Consider the significance of the SB (CT scan, length, and diameter) - Conditions supporting SB stent implantation after provisional stenting of the main vessel: 1. impaired TIMI flow in the SB 2. significant stenosis (>70%) with angina and/or ECG changes 3. extensive dissection (>type B) in the SB
Remember the step down in reference diameter from the proximal main vessel to the distal main vessel below the side branch take-off	- Size the first stent 1:1 to the distal main vessel reference diameter - Choose a stent diameter for which the platform accommodates expansion to the reference diameter of the proximal main vessel - Use of POT with balloon sized 1:1 to the proximal main vessel reference diameter - Be aware of geographical miss during POT (avoid bottle neck configuration of the stent)

Essential target	Description
Limit metal overlap	- Long segments and multiple layers of stents are associated with an increased risk of stent failure (ST and restenosis) - Presence of multiple layers of stent struts across the side branch ostium makes it more difficult to perform kissing balloon inflations - Reduce the stent overlap in DK crush and DK culotte
Achieve sufficient stent expansion	- Suboptimal stent expansion correlates with stent failure (ST and restenosis) - Stent expansion can accurately be estimated only by intracoronary imaging, but major underexpansion might be recognised by meticulous angiography revision and should be avoided - Optimal lesion preparation before stent implantation aids stent expansion - High-pressure non-compliant balloon post-dilatation of all stented segments of coronary bifurcation is recommended - Overdilate the stents by 5-10%, to compensate for recoil - - Aim for: TIMI 3 flow in the main vessel and side branch; Minimal residual stenosis in the stented segments (DS <10%).

Essential target	Description
Avoid major stent malapposition	- Major malapposition is associated with increased risk of major safety events, including cardiac death, MI and ST - Stent apposition can accurately be estimated only by intracoronary imaging but major malapposition might be recognised by meticulous angiography revision and should be avoided - Stent malapposition is most often present in the proximal main vessel of a coronary bifurcation lesion due to suboptimal POT (undersized balloon used for POT) - The presence of stent malapposition in the proximal main vessel increases the risk of abluminal wiring and stent deformation during baseline and subsequent follow-up procedures - Use a stent-enhanced view when possible - Size the devices with respect to the vascular branching laws - Consider using contrast puffing during balloon inflations when a doubt of significant undersizing exists

Updated coronary vessel sizing by angiography

- Coronary angiography encounters limitations when applied to CBL due to its inherent two-dimensional (2D) nature.
- To overcome this limitation, 2D and 3D QCA analysis software dedicated to bifurcation has been developed, and its use is strongly recommended.
- Compared to traditional QCA, ICI demonstrated superior precision and accuracy in quantitative assessments.

Table 2. Target diameters of the reference segments obtained by adjusting QCA values in the GUIDE DES trial.

QCA-estimated reference vessel diameter	Target vessel estimation
≤3.5 mm	QCA-estimated reference vessel diameter+10%
>3.5 mm and <4.0 mm	QCA-estimated reference vessel diameter+6-9%
≥4.0 mm	QCA-estimated reference vessel diameter+5%

DES: drug-eluting stent; QCA: quantitative coronary angiography

- In GUIDE DES trial , an “adjusted” angiographic stent-sizing approach was employed for the first time. This protocol involved adjusting software-measured QCA reference vessel diameters by applying a 5-10% oversizing to create target diameters for stent sizing and post-dilatation

Technical basics for stent selection and deployment

- THE DYNAMIC NATURE OF THE EXPANSION OF BALLOONS AND STENTS

- Manufacturers’ charts typically indicate the pressure required to reach the stent diameter achievable with sustained (>20-30 sec) inflation at a specific pressure.

- STENT ADAPTATION TO THE BIFURCATION ANATOMY BASED ON A STENT'S EXPANSION POTENTIAL

- It is essential to choose a stent platform that is suitable for both the pMV and the dMV in order to achieve optimal stent deployment.

Table 3. Compliance charts for common DES platforms.

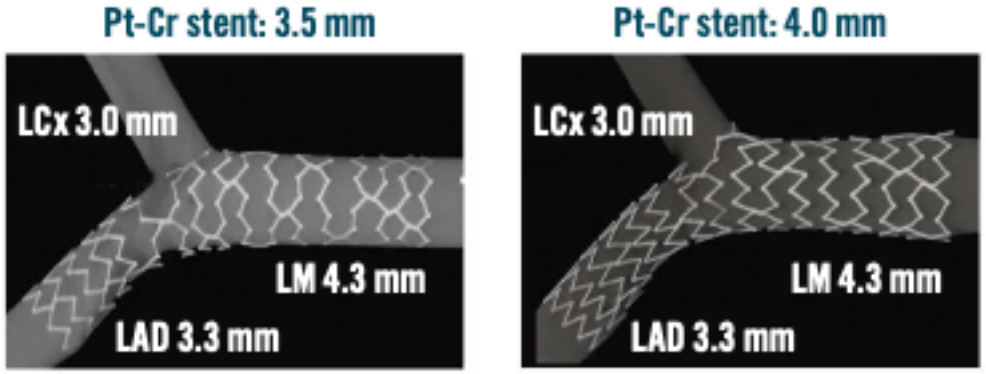
DES platform	Nominal size range for each platform	Minimal expansion diameter (according to manufacturers' chart)	Maximal overexpansion diameter with appropriately sized postdilatating balloon (on-label use)
XIENCE Skypoint[1]	2.0-3.0 mm	2.05 mm (for 2.0 mm stent @ 8 atm)	3.75 mm
XIENCE Skypoint[1]	3.5-5.0 mm	3.36 mm (for 3.5 mm stent @ 8 atm)	5.75 mm
Onyx Frontier[2]	2.0-2.5 mm	1.89 mm (for 2.0 mm stent @ 7 atm)	3.00 mm
Onyx Frontier[2]	2.75-3.0 mm	2.50 mm (for 2.75 mm stent @ 7 atm)	4.00 mm
Onyx Frontier[2]	3.5-4.0 mm	3.20 mm (for 3.5 mm stent @ 7 atm)	5.00 mm
Onyx Frontier[2]	4.5-5.0 mm	4.10 mm (for 4.5 mm stent @ 7 atm)	6.00 mm
SYNERGY XD[3]	2.25-2.75 mm	2.05 mm (for 2.0 mm stent @ 8 atm)	3.50 mm
SYNERGY XD[3]	3.0-3.5 mm	3.05 mm (for 3.0 mm stent @ 8 atm)	4.25 mm
SYNERGY XD[3]	4.0 mm	3.88 mm (for 4.0 mm stent @ 8 atm)	5.75 mm
SYNERGY MEGATRON[3]	3.5-5.0 mm	3.18 mm (for 3.5 mm stent @ 8 atm)	6.00 mm
Ultimaster Nagomi[4]	2.0-2.5 mm	1.84 mm (for 2.0 mm stent @ 7 atm)	3.50 mm
Ultimaster Nagomi[4]	2.75-3.0 mm	2.56 mm (for 2.75 mm stent @ 7 atm)	4.50 mm
Ultimaster Nagomi[4]	3.5-4.5 mm	3.26 mm (for 3.5 mm stent @ 7 atm)	6.25 mm
Orsiro Mission[5]	2.25-3.0 mm	2.31 mm (for 2.25 mm stent @ 8 atm)	3.5 mm
Orsiro Mission[5]	3.5-4.0 mm	3.56 mm (for 3.5 mm stent @ 10 atm)	4.5 mm

[1]Abbott; [2]Medtronic; [3]Boston Scientific; [4]Terumo; [5]BIOTRONIK. DES: drug-eluting stent

- a bench test study by Hikichi et al has demonstrated that choosing a bigger stent platform, with a nominal size close to the reference diameter of the pMV (instead of the segment), is associated with a more favourable stent configuration, resulting in a reduced incidence of incomplete stent apposition and better vessel coverage.

- The stent is first implanted at below nominal pressure, avoiding overexpansion of the dMV.
- Subsequently, the pMV stent segment is expanded with a 1:1-sized balloon.

- This technique has been recently proposed to treat patients presenting a major size mismatch between the LM (large diameter) and proximal LAD, with a novel extra-large drug-eluting stent (DES) platform



Bench test comparison of final stent conformation obtained by provisional stenting using two different stent platforms by the same manufacturer. A) SYNERGY (Boston Scientific) 3.5 mm×20 mm DES implanted at nominal pressures followed by POT and kissing. B) SYNERGY (Boston Scientific) 4 mm×20 mm DES implanted at low pressure followed by POT and kissing. Cr: chromium;
DES: drug-eluting stent; LAD: left anterior descending artery; LCx: left circumflex artery; LM: left main artery; POT: proximal optimisation technique; Pt: platinum

Enhanced assessment of stent conformation during bifurcation PCI

- The final goal of bifurcation PCI is to restore the native anatomy/physiology of the bifurcation and to minimise metal coverage (stented areas).

- A recent innovation involves a technique where a small contrast injection is delivered during the stent post-dilatation phase, aiming to detect balloon undersizing in angiography- guided procedures
- When contrast is able to bypass the inflated balloon, creating a “distal puff sign”, a substantial gap between the stent/balloon and vessel wall, indicating major malapposition, is likely. This phenomenon has been named the “POT-puff sign” when observed during POT
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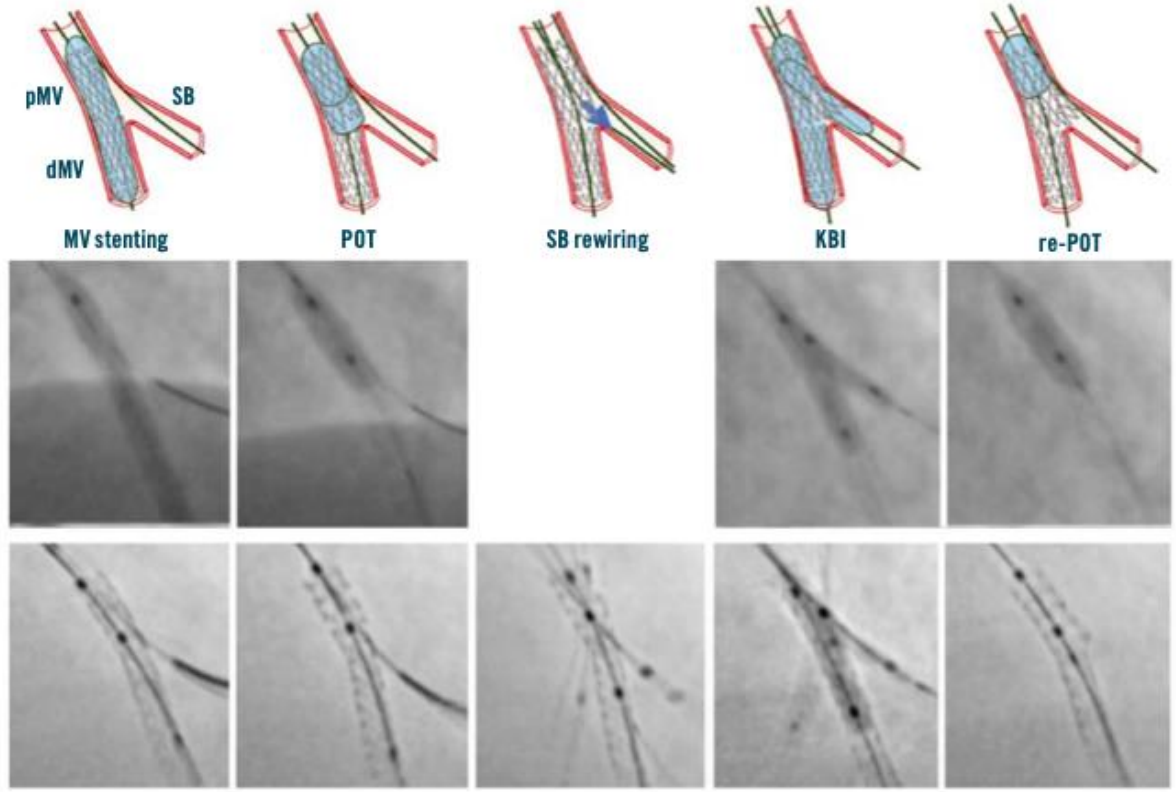
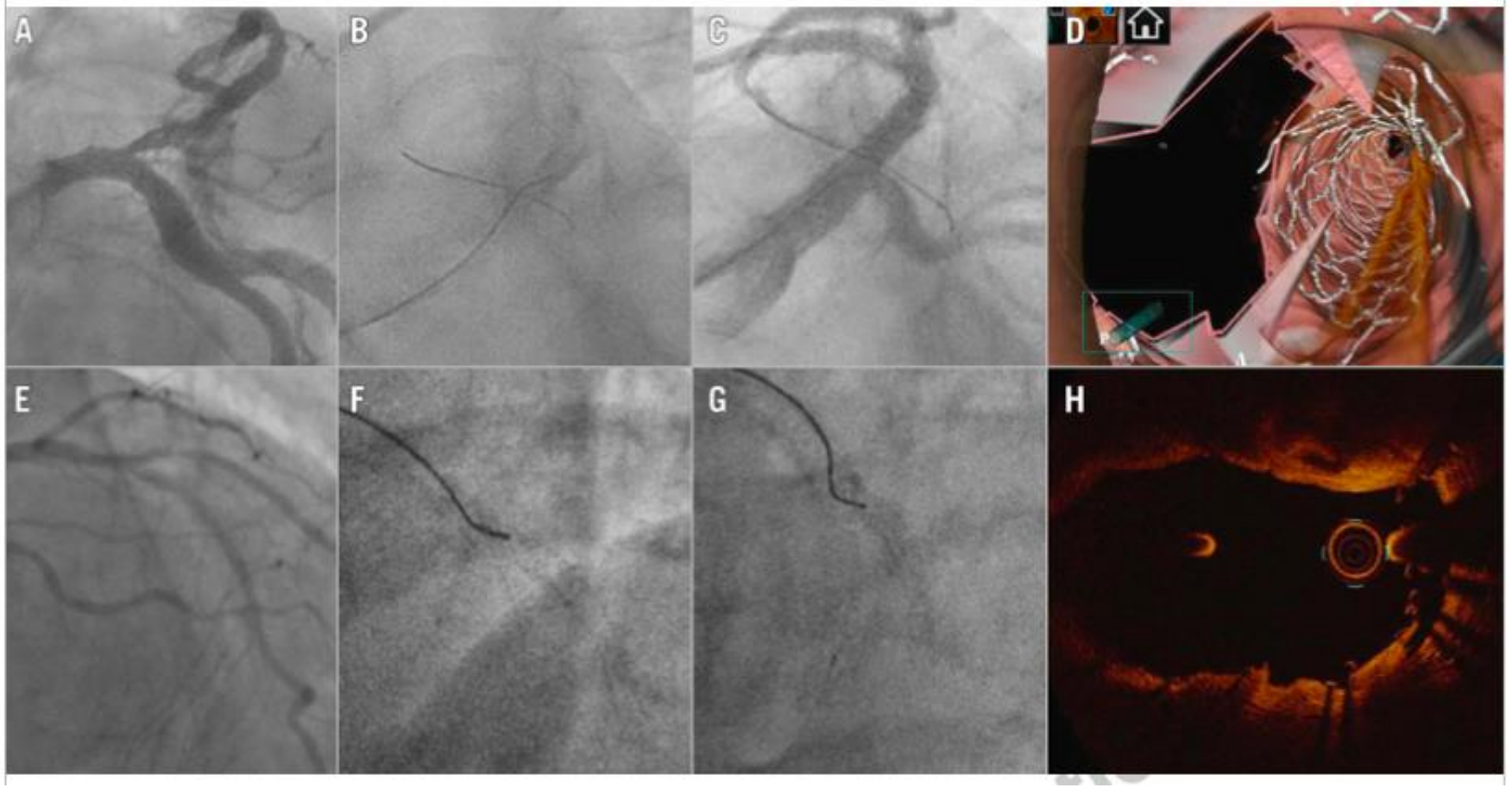


Figure 3. *Sequence of stepwise provisional stenting and its clinical performance with step-by-step stent enhancement. dMV: distal main vessel; KBI: kissing balloon inflation; MV: main vessel; pMV: proximal main vessel; POT: proximal optimisation technique; SB: side branch*

SB rewiring site check

1. In stepwise provisional procedures (including those completed with double stenting according to T/TAP or culotte), the most favourable SB rewiring site is distal (close to the bifurcation carina);
2. In crushing procedures, SB rewiring should be non-distal (away from the bifurcation carina).

- OCT-guided distal rewiring has been proven to be associated with more favourable stent healing

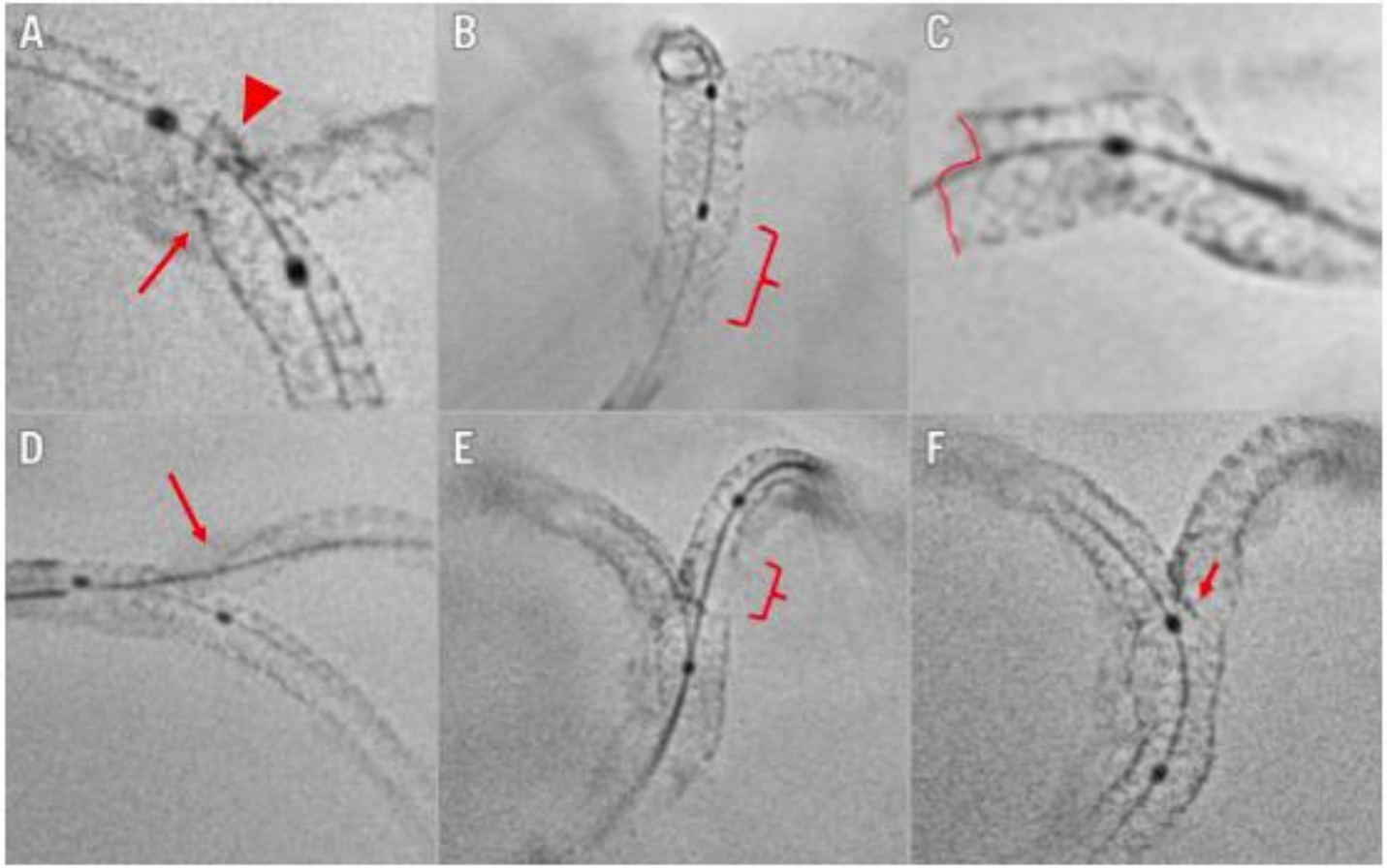


Optimal SB rewiring site check by angiography resulting in good OCT results after 1-stent (A-D) and 2-stent techniques (E-H). A) Baseline angiography in a patient treated by provisional. B) "Pullback rewiring" manoeuvre.
C) Angiography confirming the achievement of distal rewiring. D) Post-PCI 3D OCT showing wide opening of the side branch. E) Baseline angiography in a patient treated by DK crush. F) Advancement of the wire towards the side branch ostium after balloon crush; G) Fluoroscopic image confirming the "non-distal" rewiring site. H) Post-PCI OCT at the level of bifurcation showing optimal crushing of the side branch stent.

Procedural complications during angiography-guided PCI

- As a common example, resistance when advancing the SB balloon through the MV stent struts may arise from inadequate POT, wire wrapping, or abluminal MV stent wiring.

- whenever a procedural issue arises, and angiographic assessment or stent enhancement fail to elucidate its cause, operators should consider the use of ICI (IVUS or OCT according to operator experience) to better identify the aetiology and optimise the result.



Suboptimal stent implantation revealed by stent enhancement imaging during bifurcation PCI.

A) Stent underexpansion caused by the calcified plaque (arrow); the incomplete crush of the SB stent (arrowhead).

B) Incomplete POT in the proximal segment of the LM stent (brace).

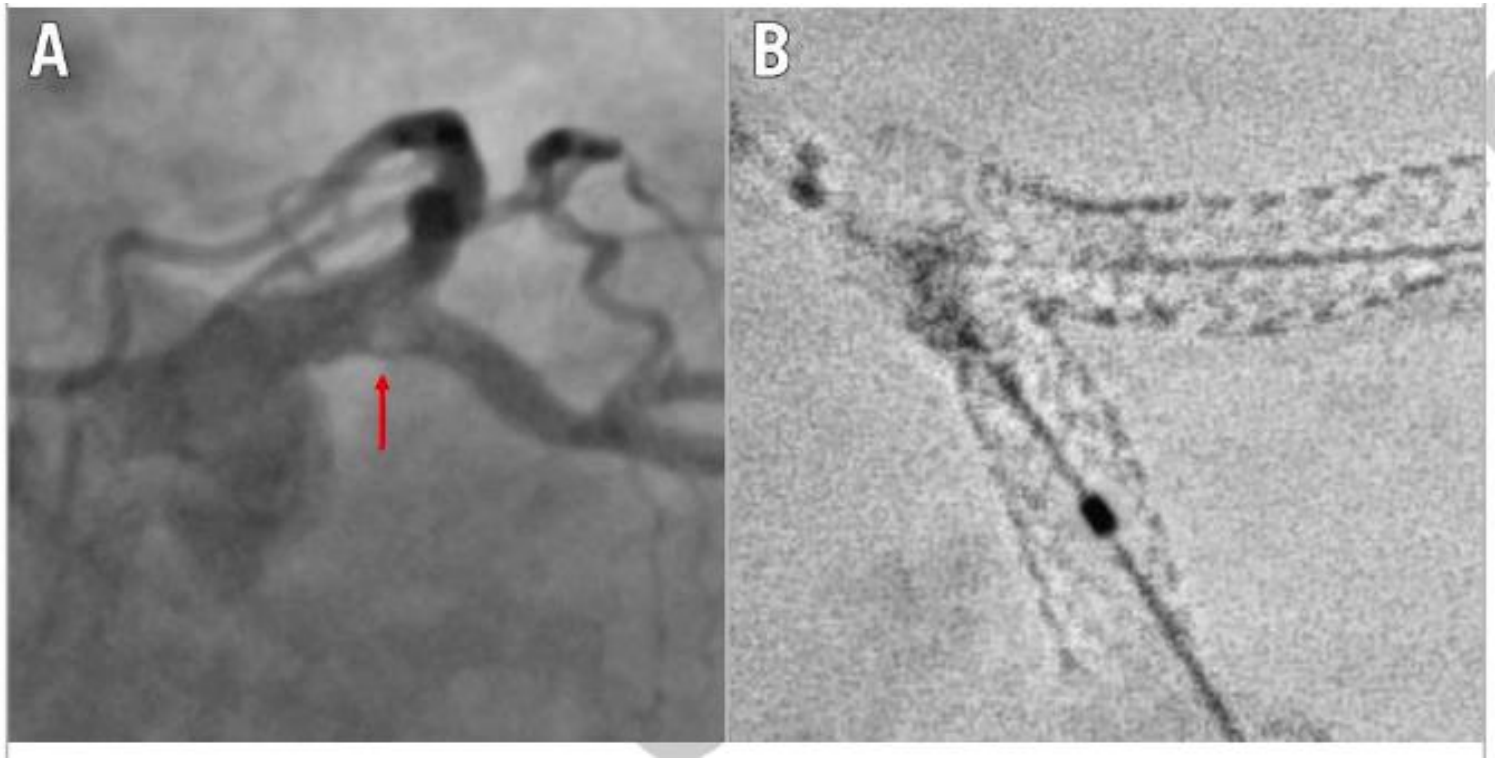
C) Partial stent deformation caused by the guiding catheter at the LM ostium.

D) Uncovered SB ostium (arrow) due to a too distal stent implantation.

E) Abluminal SB rewiring and SB stent deformation after kissing balloon inflation (brace).

F) Neocarina displacement (arrow) towards the SB ostium caused by a too distal final POT.

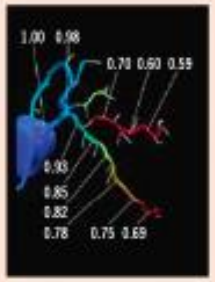
G) LM: left main artery; PCI: percutaneous coronary intervention; POT: proximal optimisation technique; SB: side branch



Example of recognised cause for intraprocedural thrombus formation during a 2-stent bifurcation stenting procedure. A) Intraprocedural angiography showing filling defect (arrow) at the SB ostium during a DK crush procedure on the LM. B) Stent enhancement revealing major deformation after kissing balloon inflation due to abluminal LM stent wiring. DK: double-kissing; LM: left main artery; SB: side branch

Key points for achieving an optimal angiography-guided PCI.

Before PCI

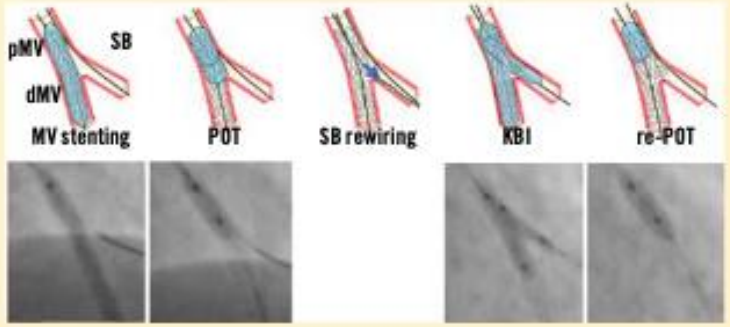


Revision of CT imaging (if available)

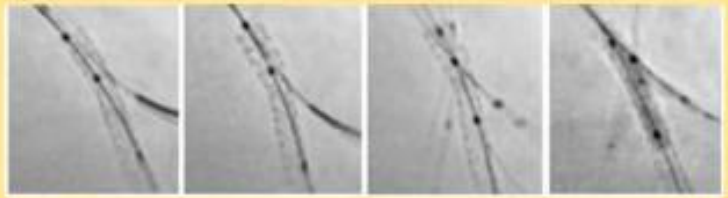
Meticulous assessment of angiography for PCI planning

Careful estimation of bifurcation segments' reference vessel diameters

During PCI



Systematic application of the technical steps reported for the selected technique

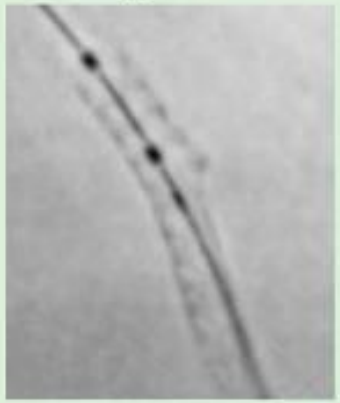


Intraprocedural use of stent enhancement tools

In the case of any technical problem with an unrecognised cause, bailout use of IVUS or OCT

Optimal angiographic result

TIMI 3 flow in both branches with full expansion of the implanted stent(s) & no severe dissection of non-stented segment(s)



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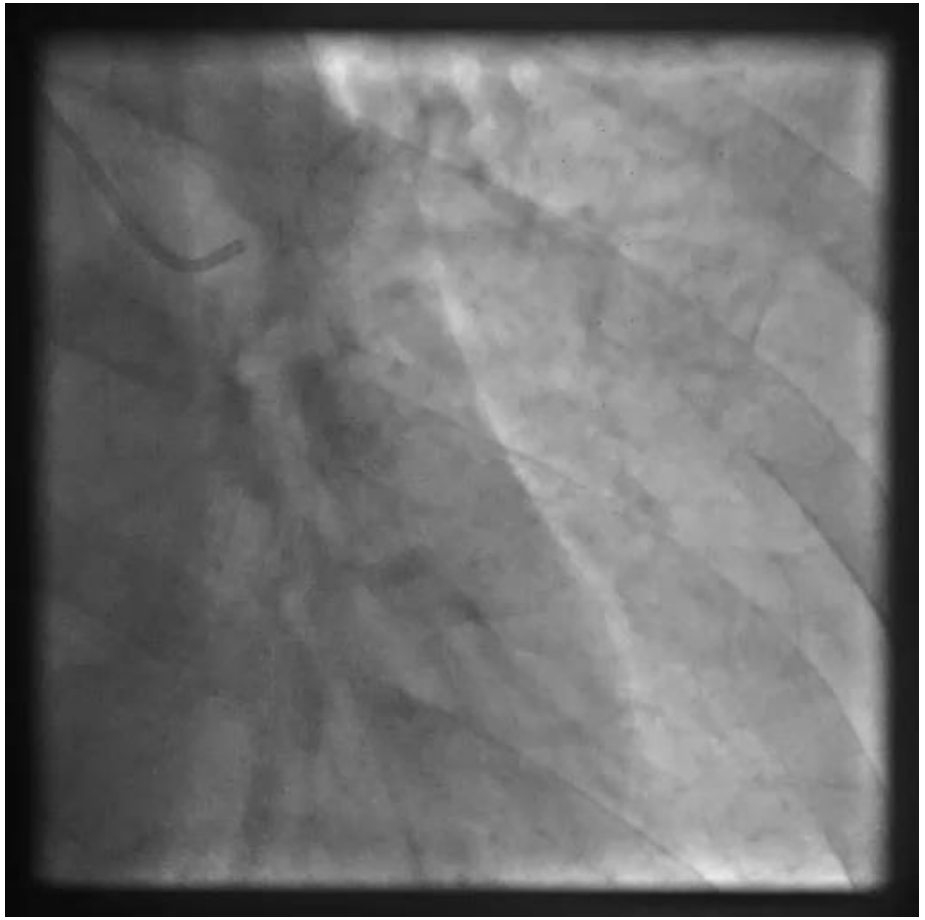
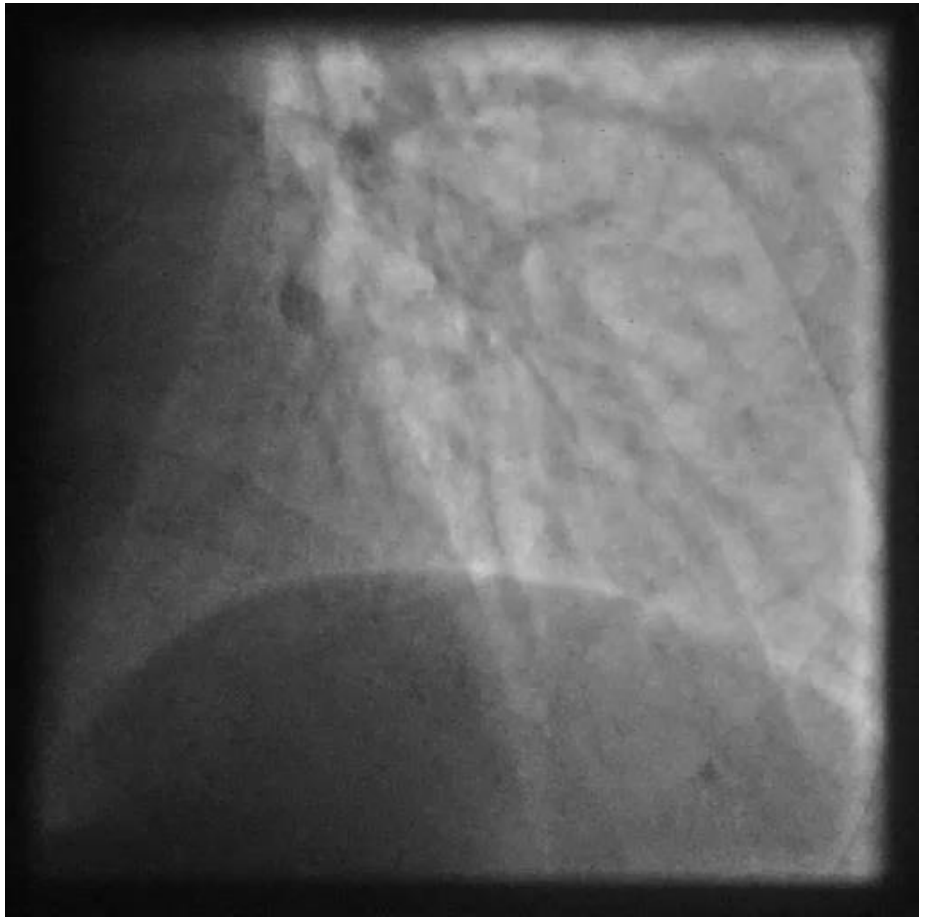
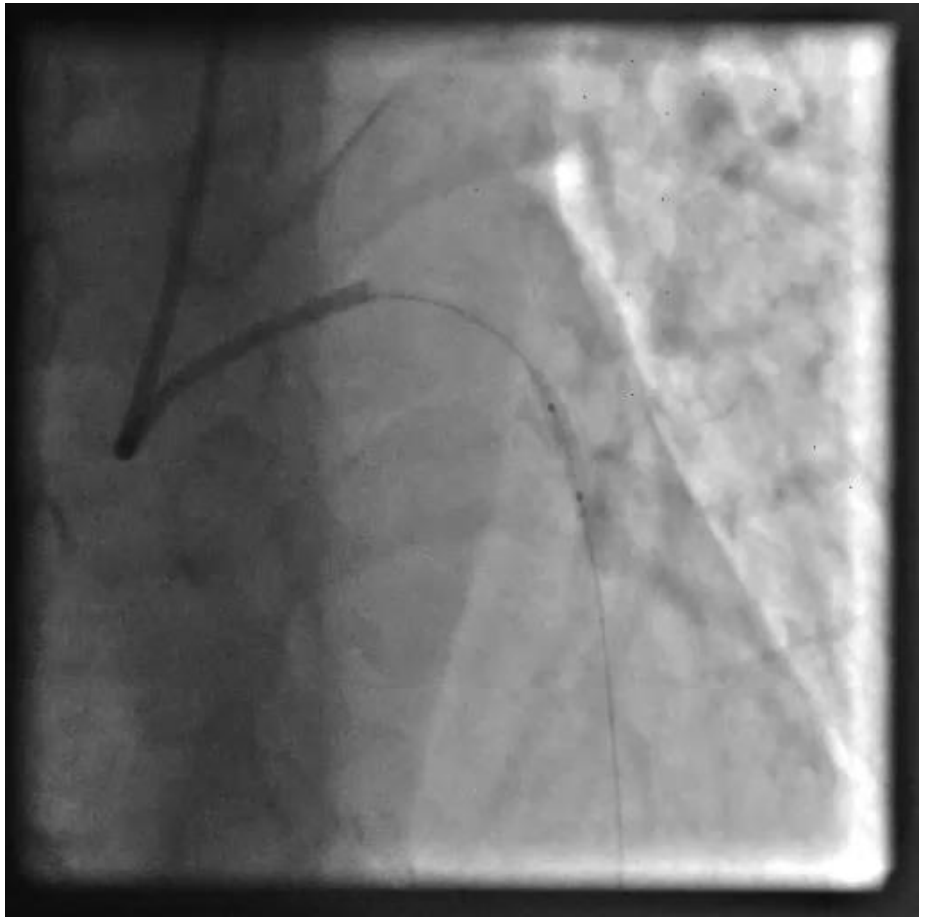
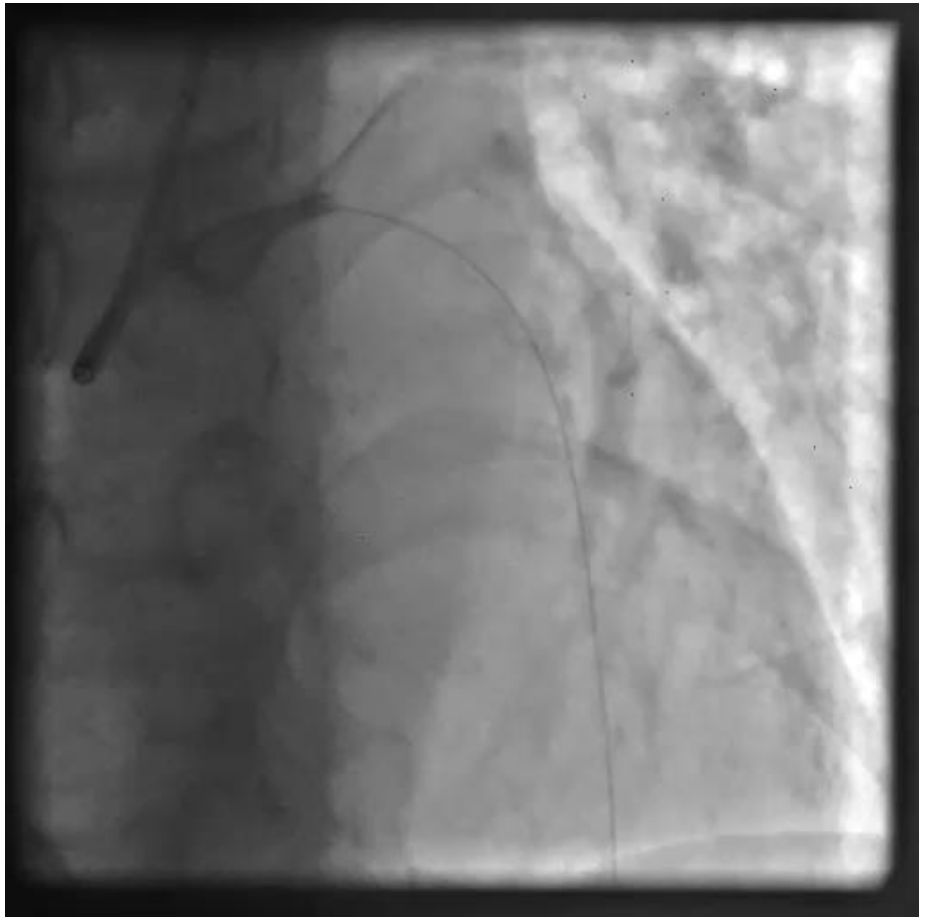




- What’s your plan?





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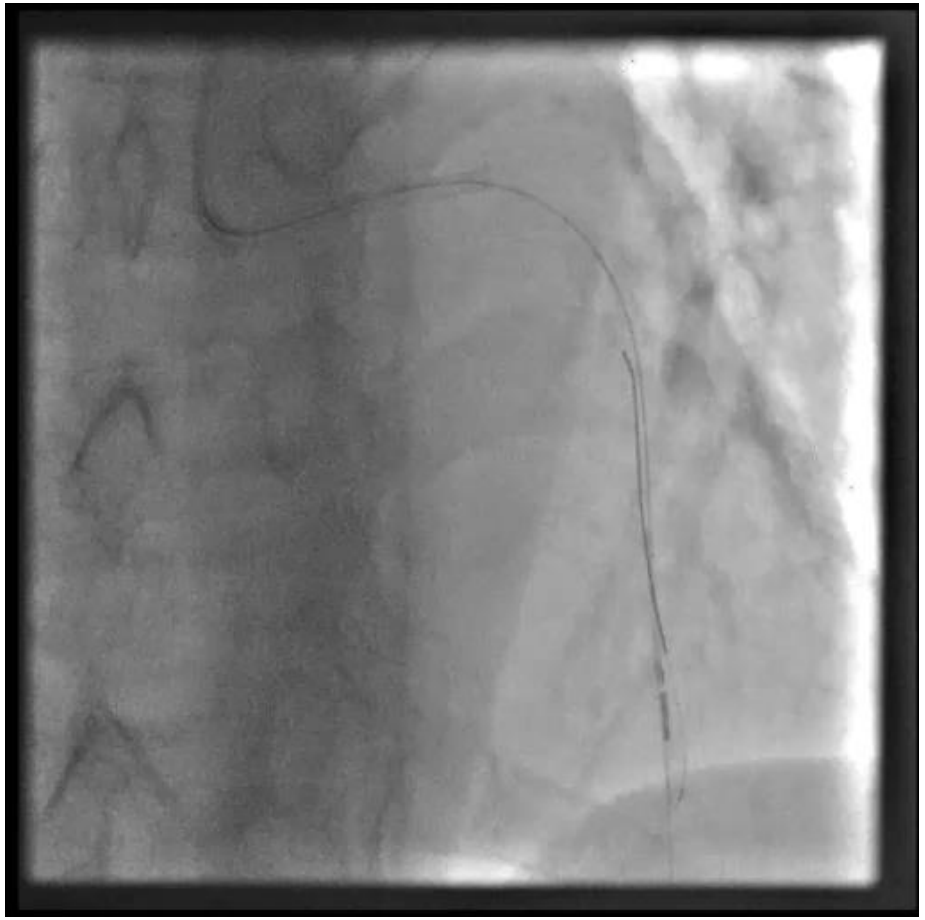
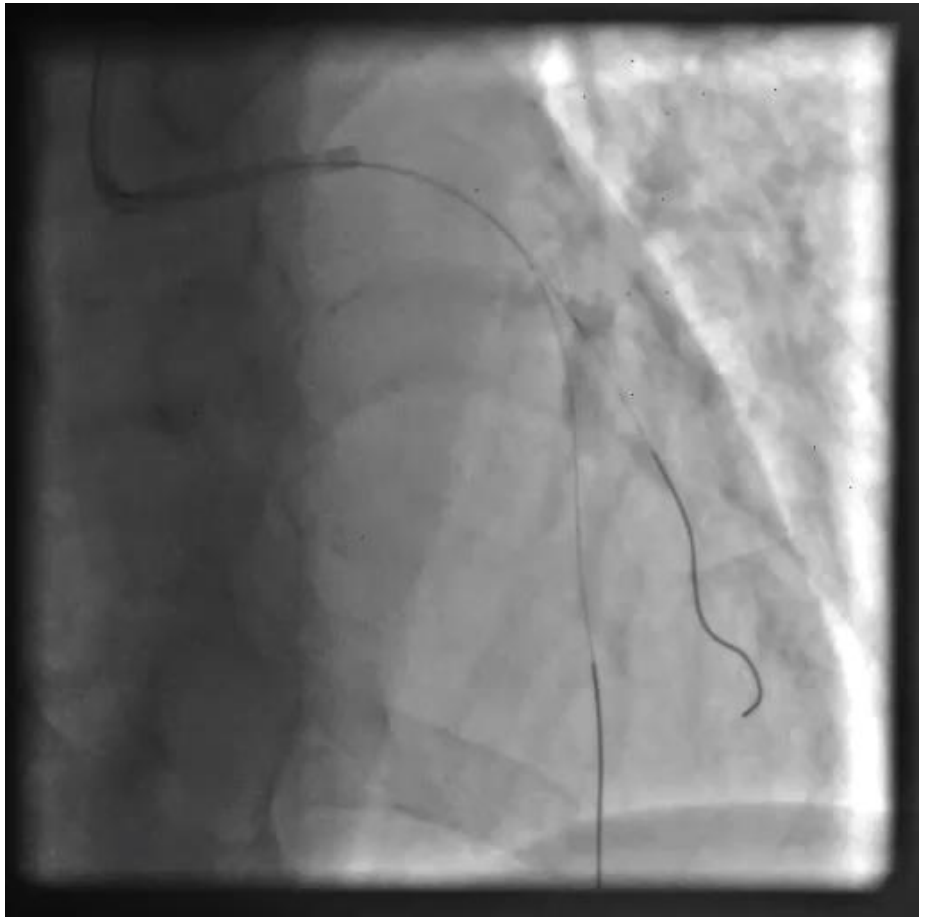
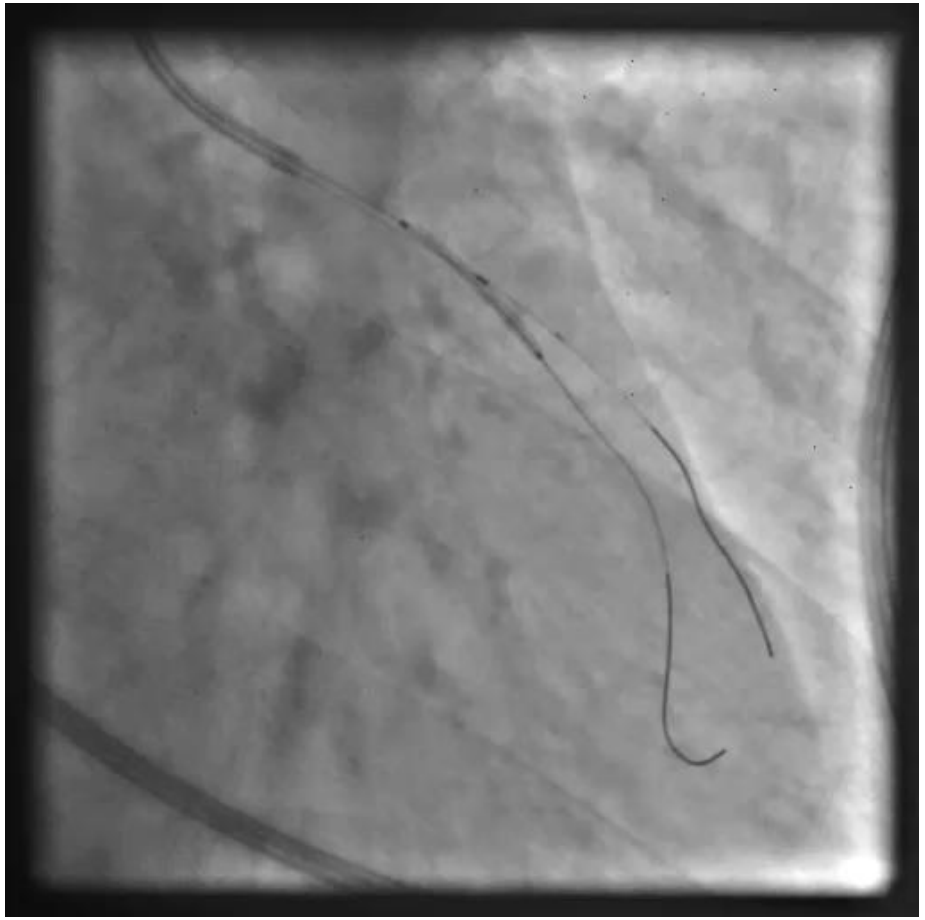
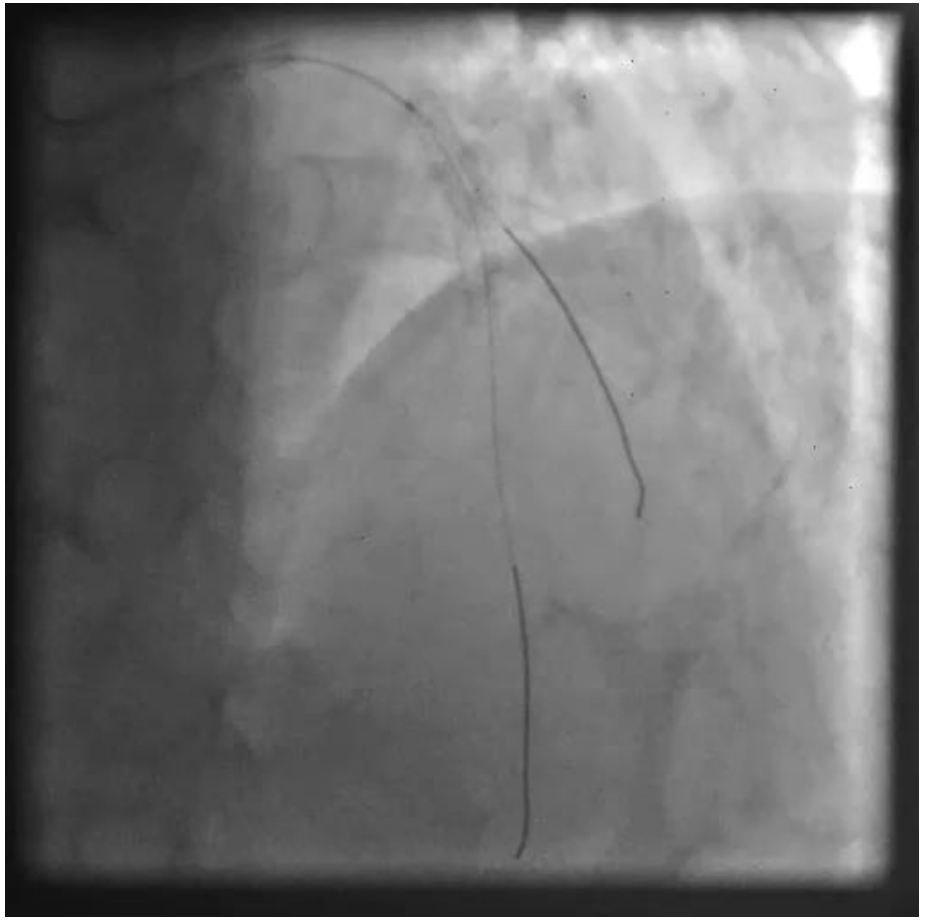
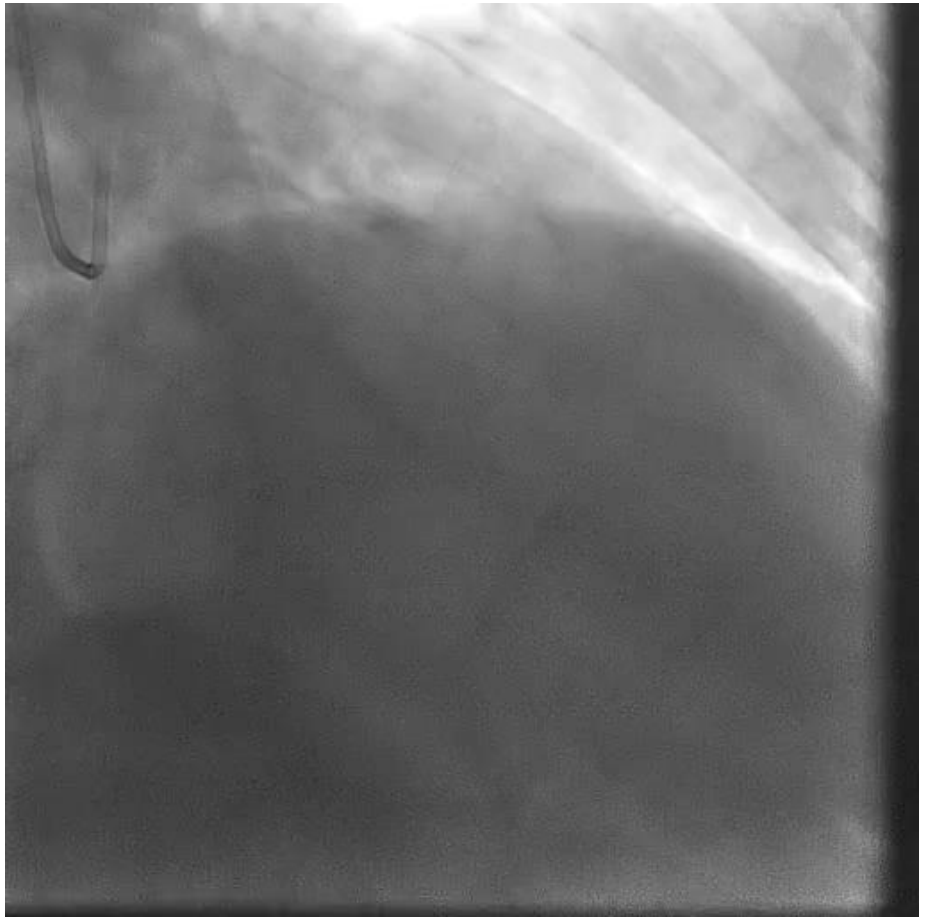


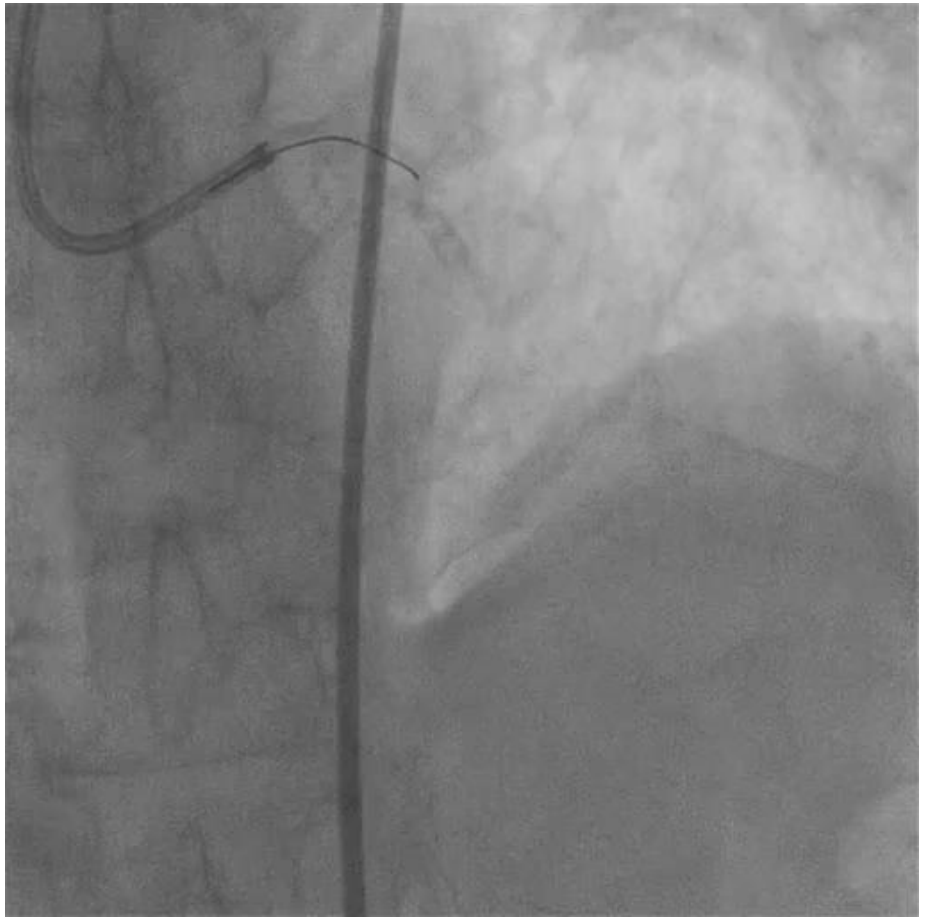


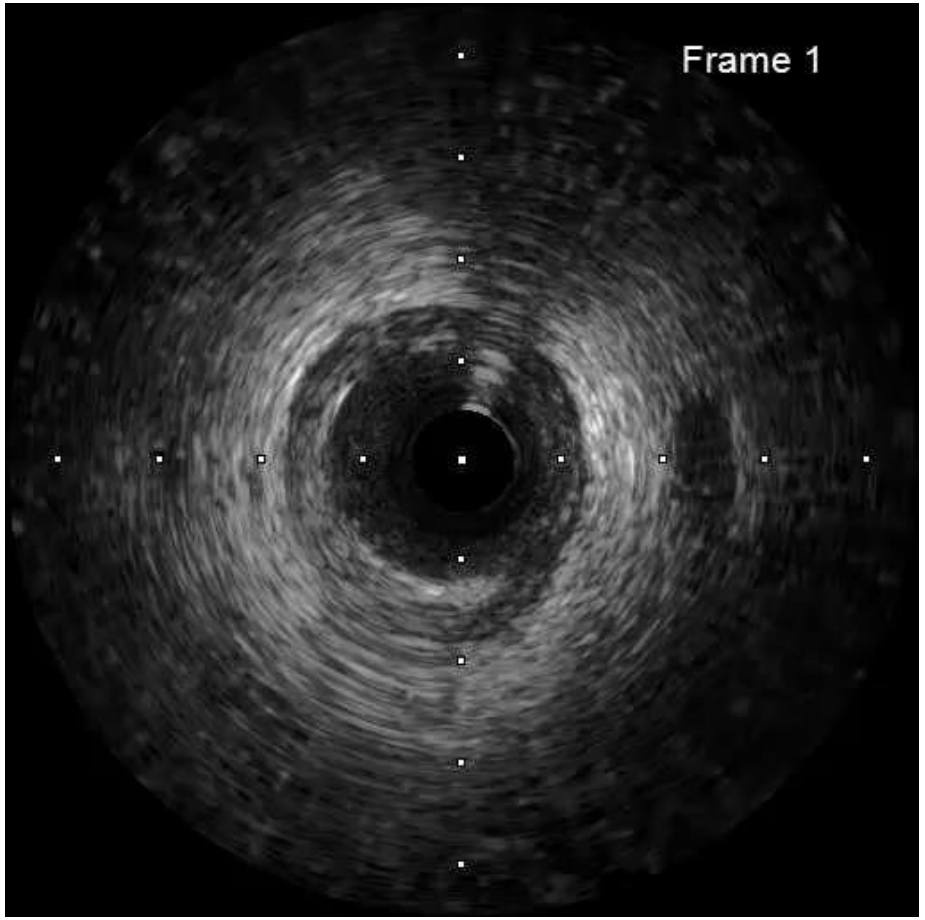




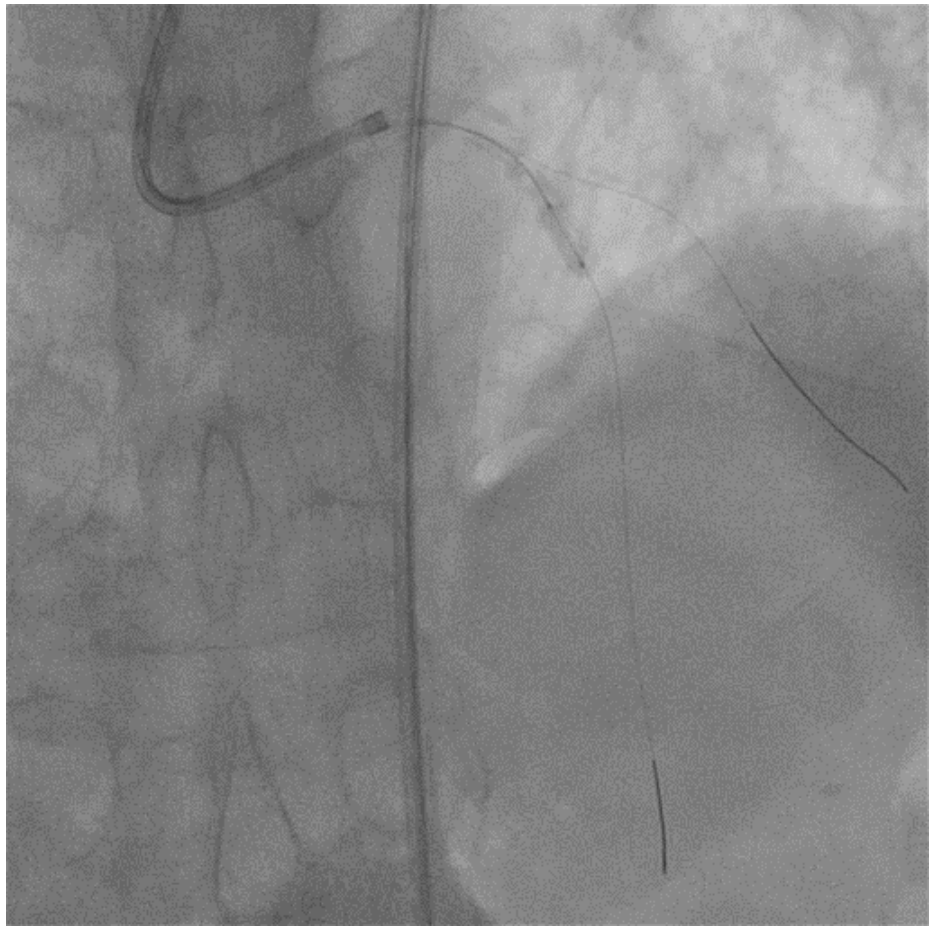
Case 2



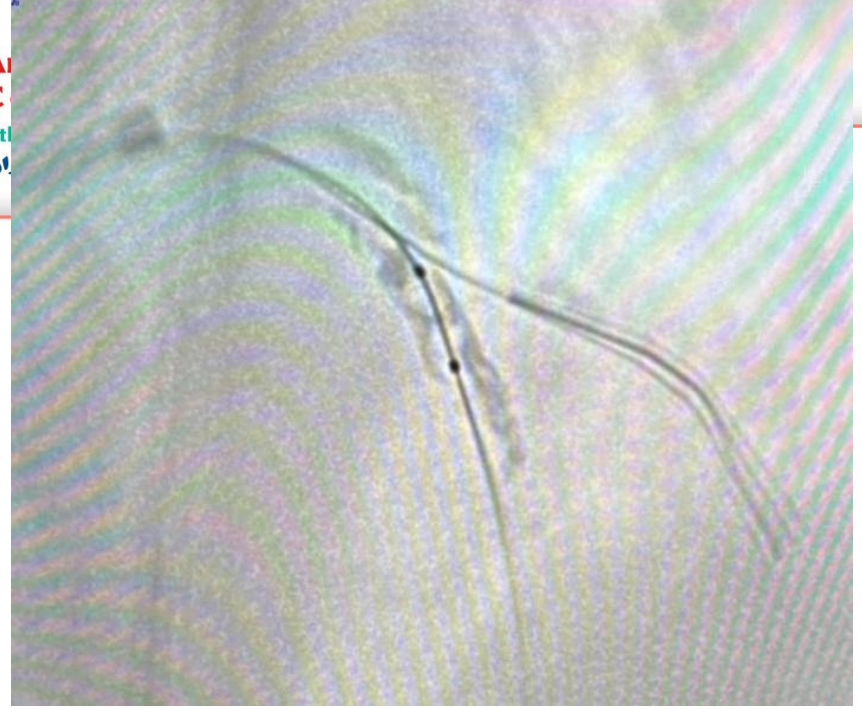


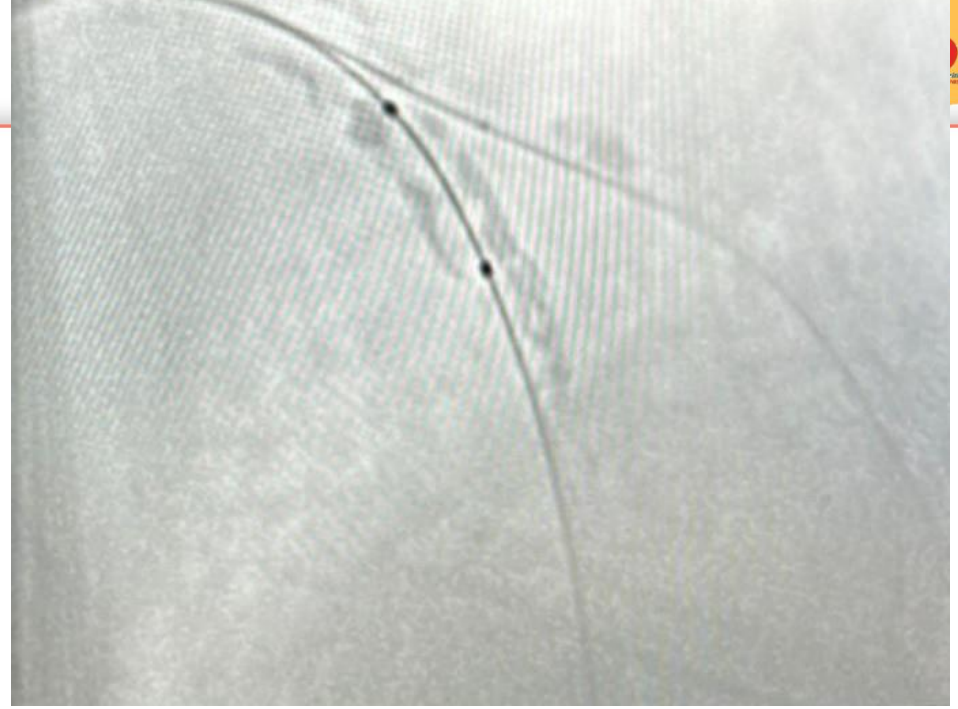

Frame 1

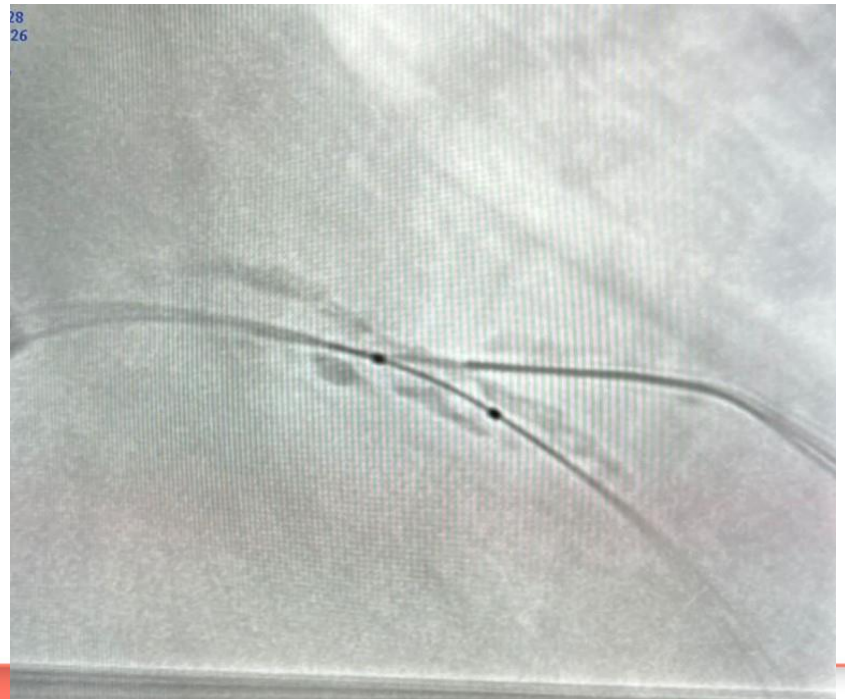
- What’s your plan?

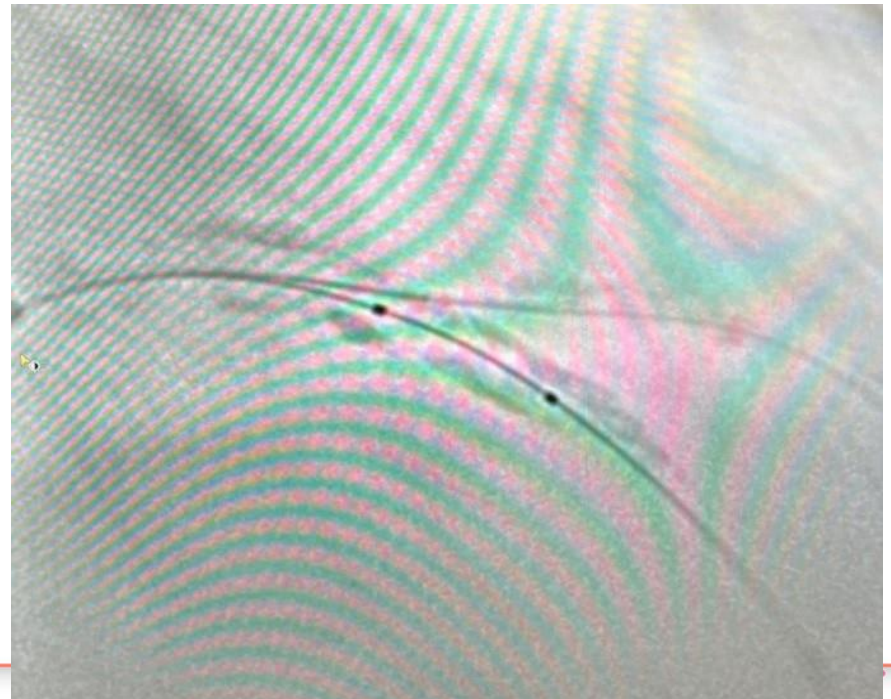


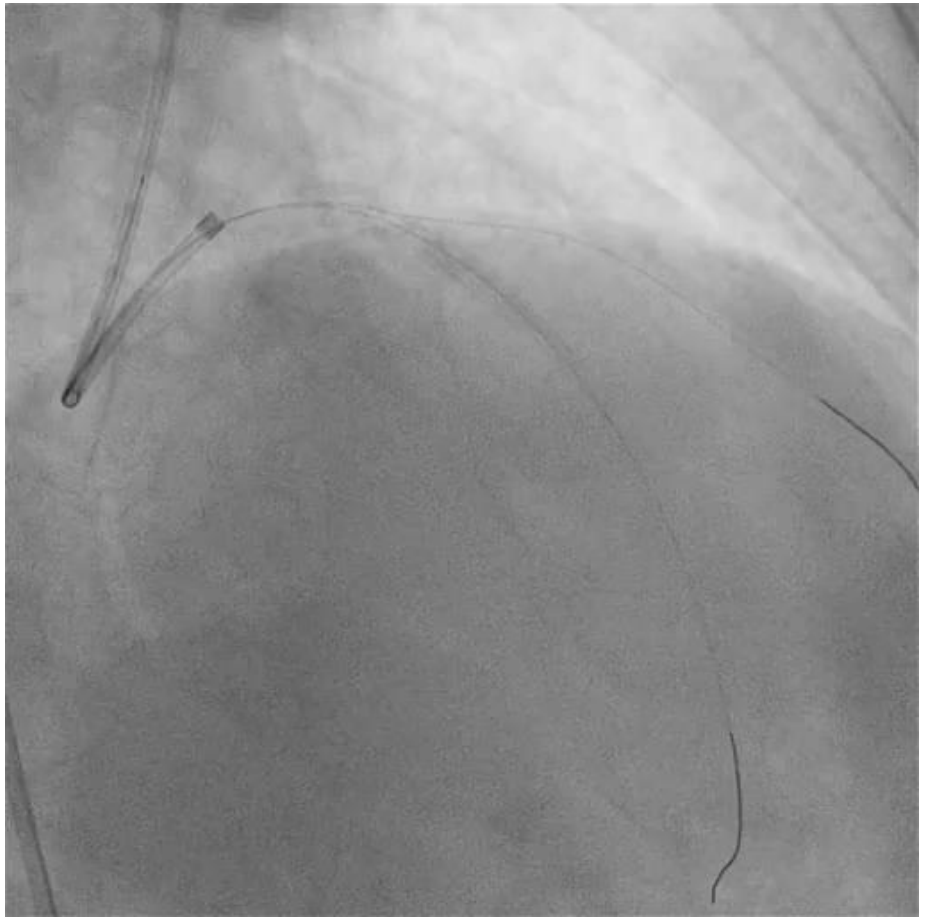
Shunmei C-IVL 2.5*12 mm

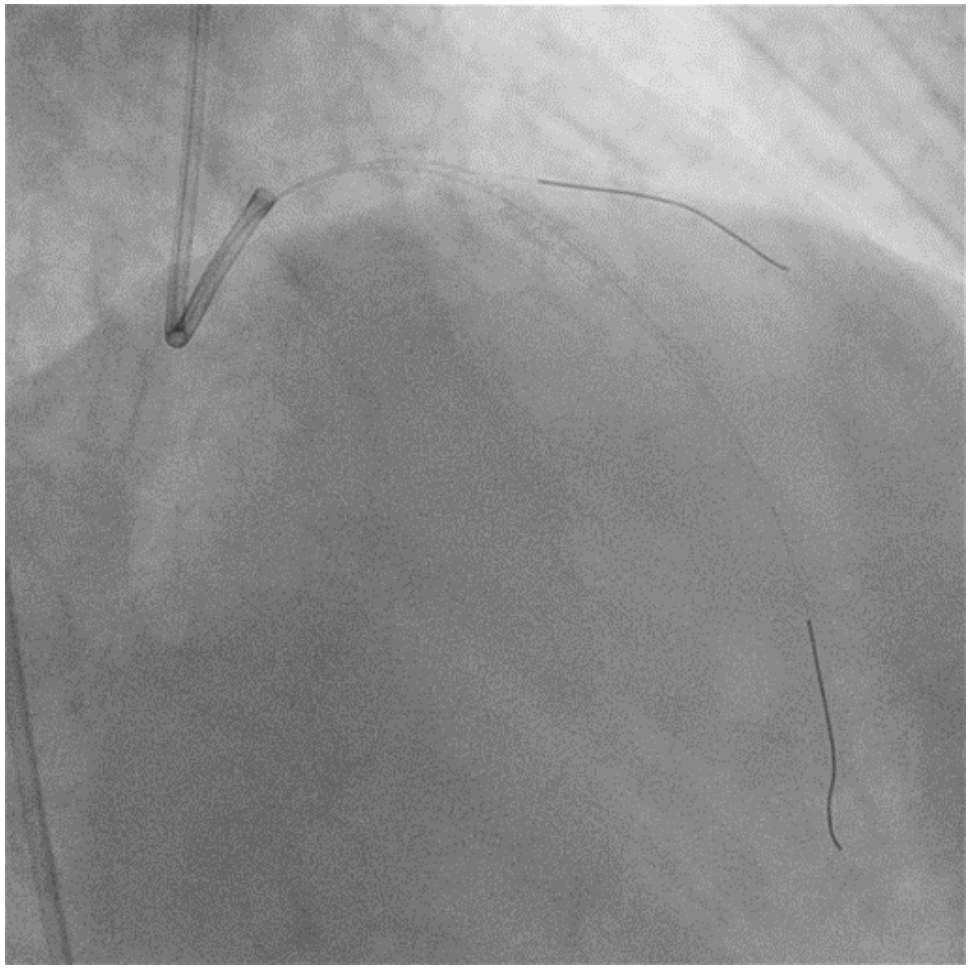


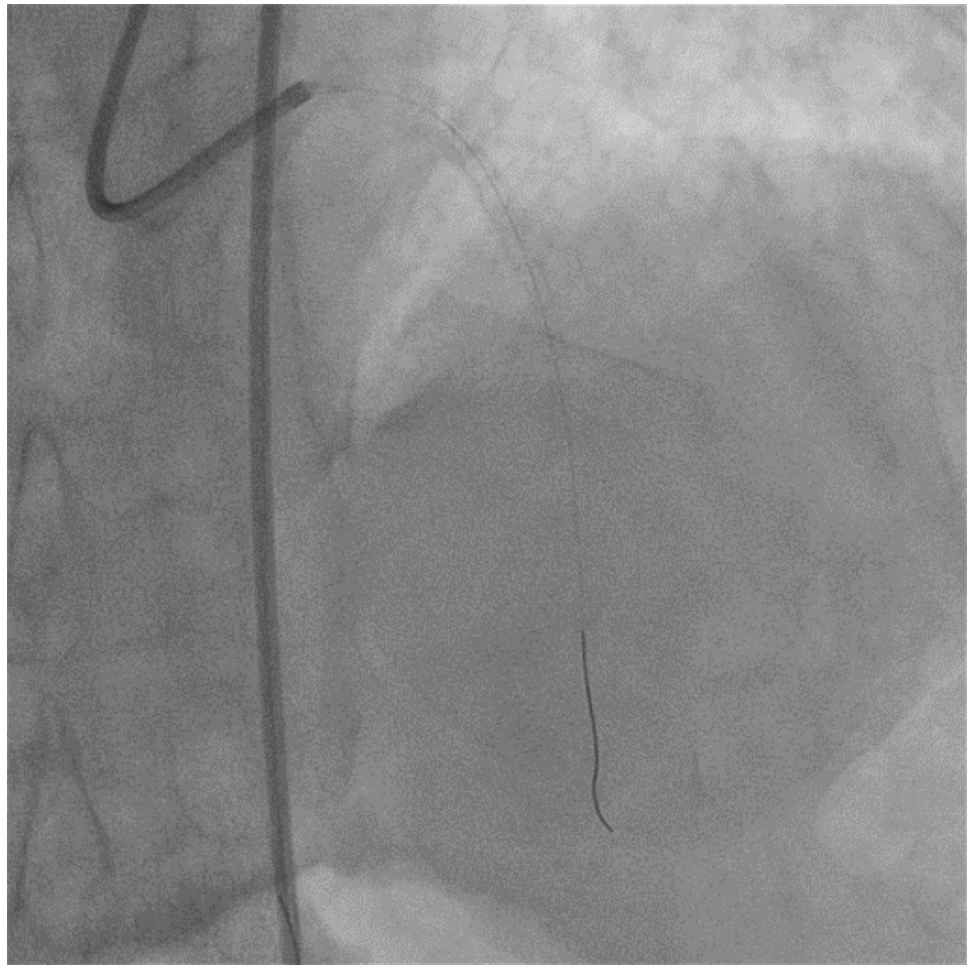




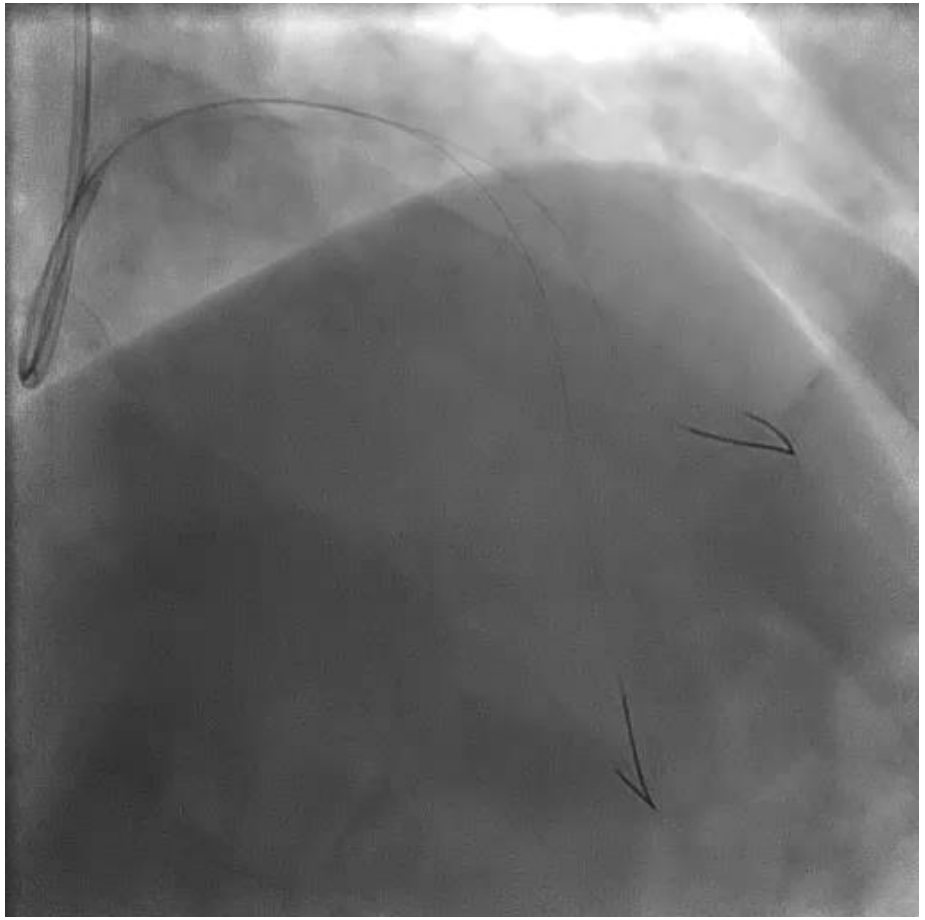








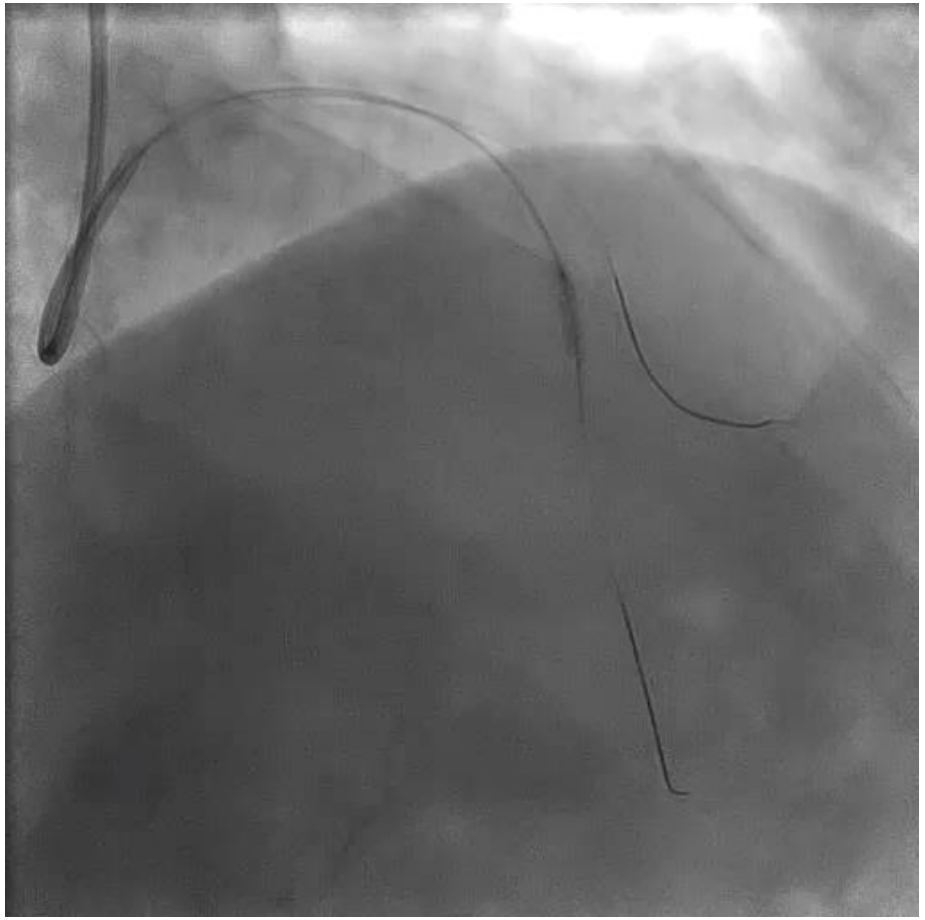
Case 3

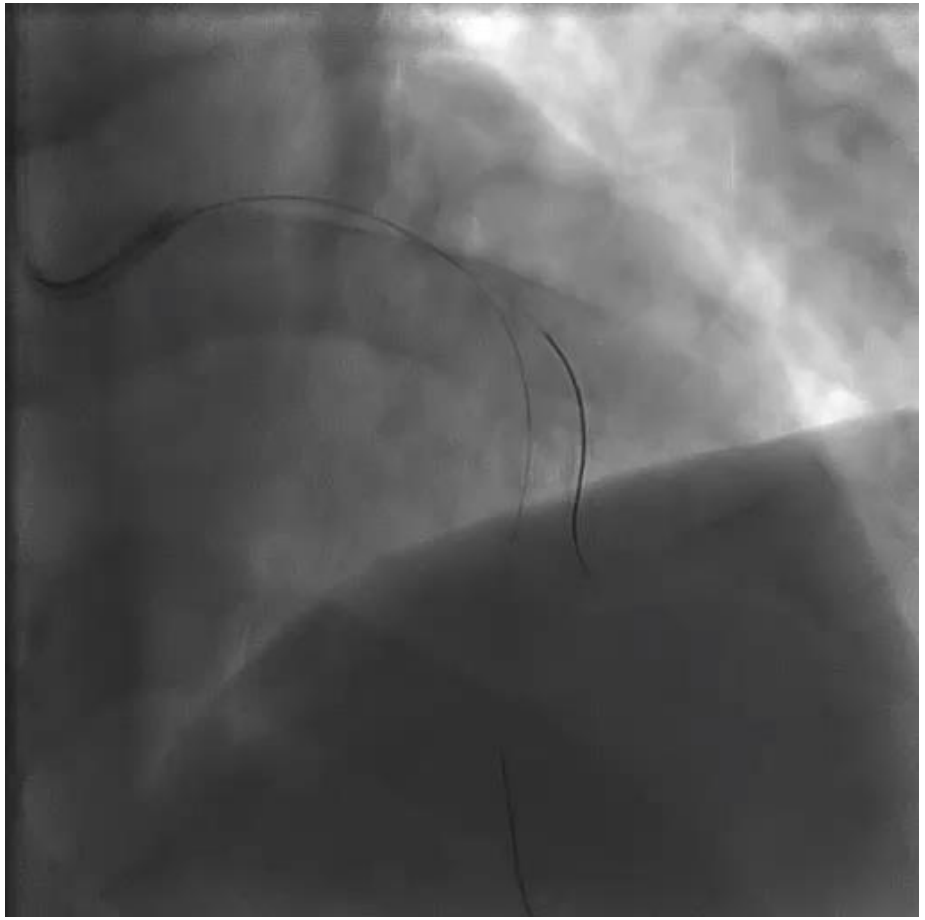


- In another center:
- Several attempts for crossing of stent from calcified LAD lesion after pre-dilation with NC balloon were failed.

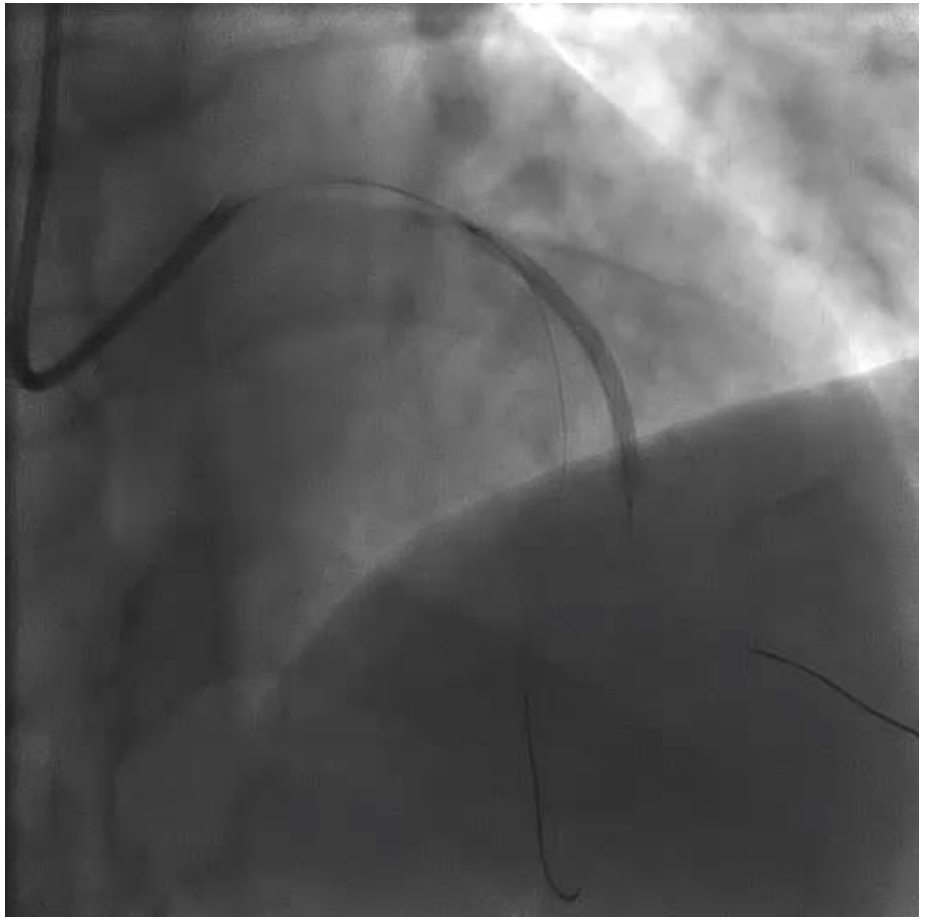
- What’s your plan?

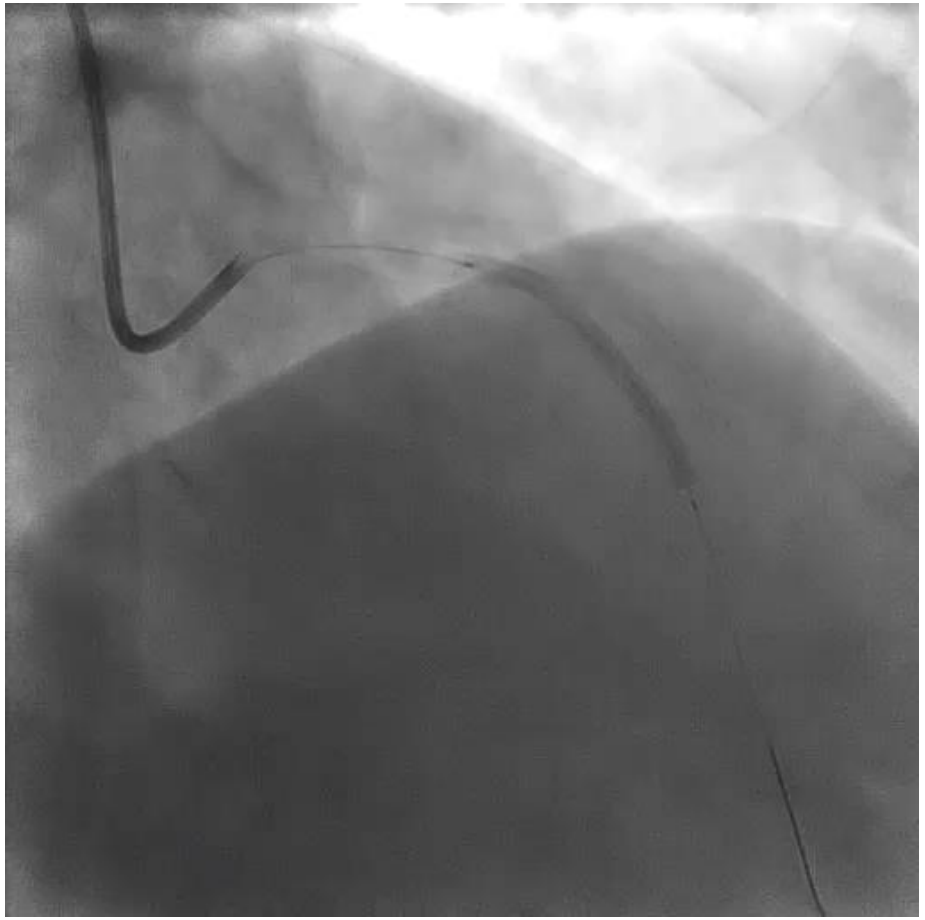
Shunmei C-IVL 2.5*12 mm

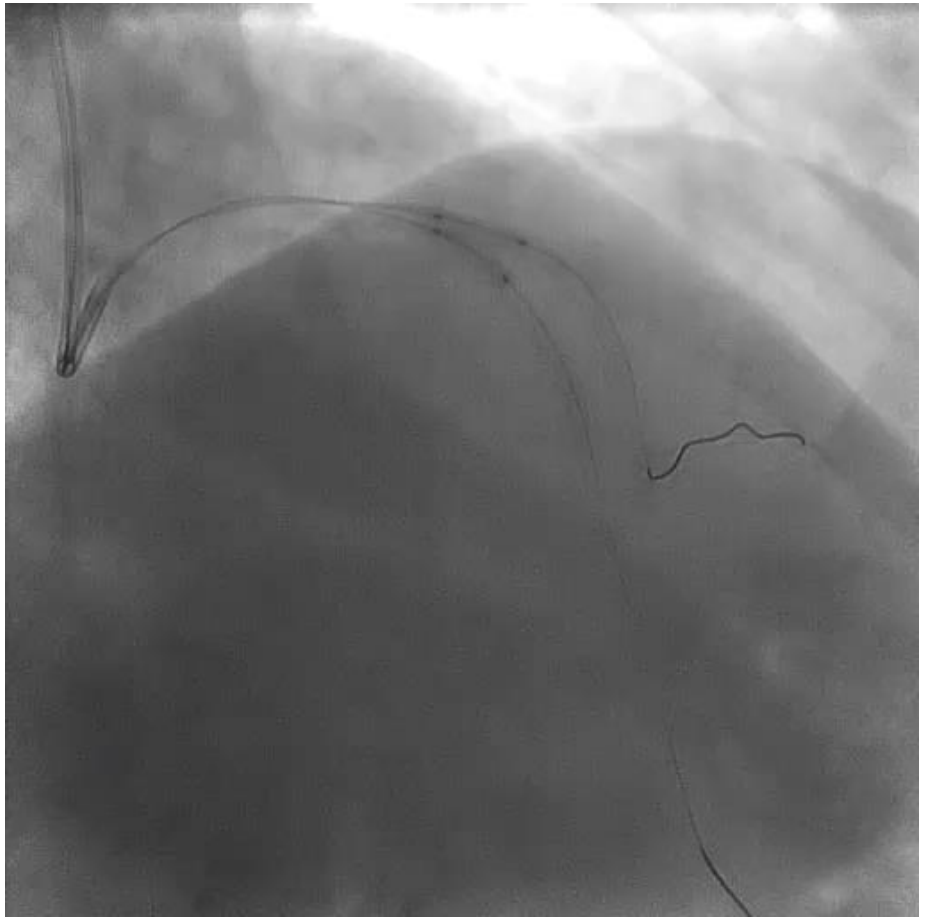


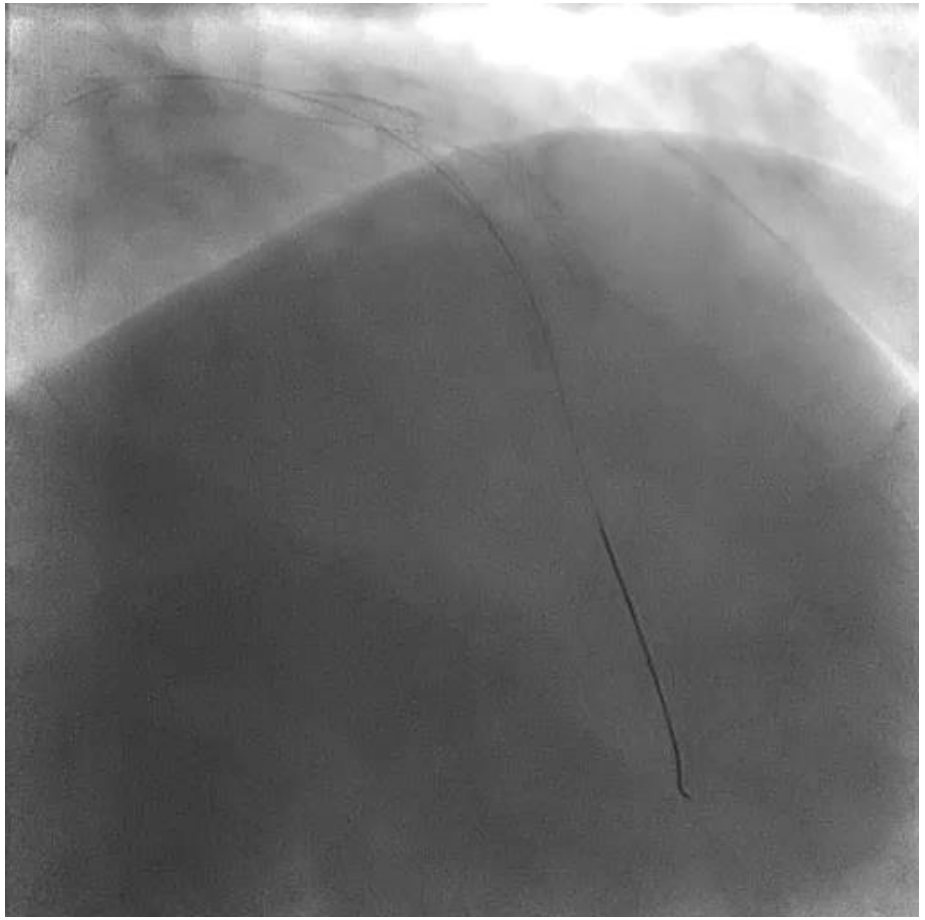


- What’s your plan?

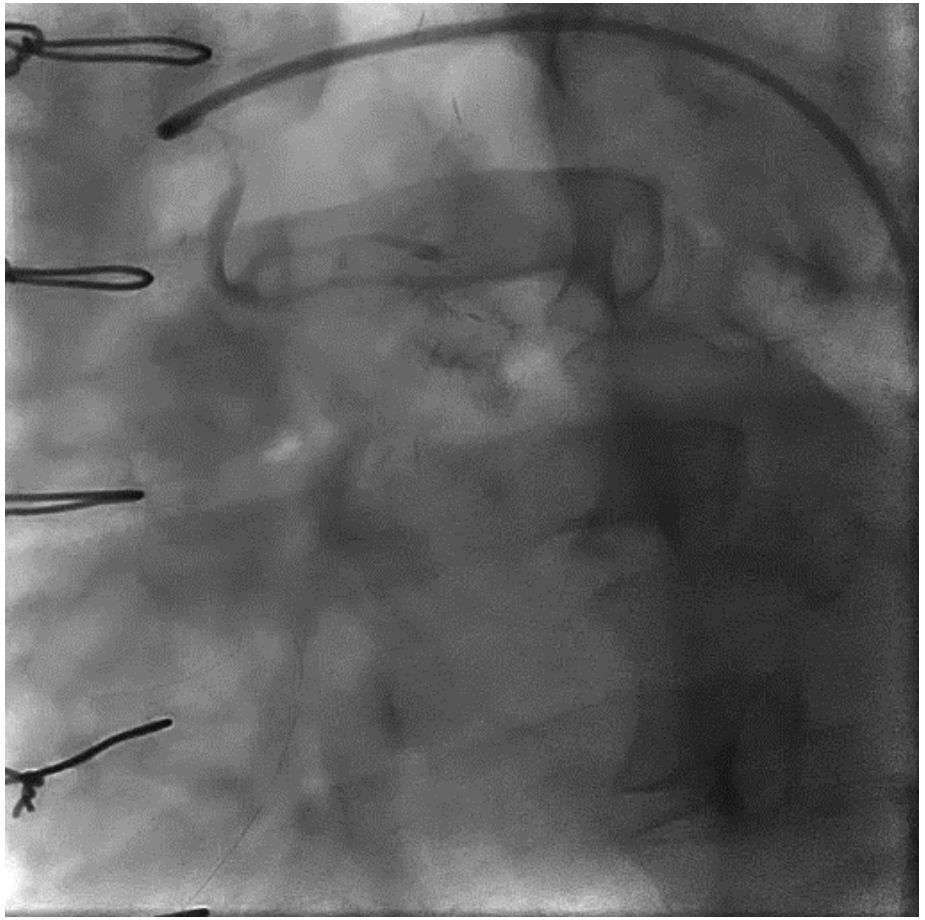


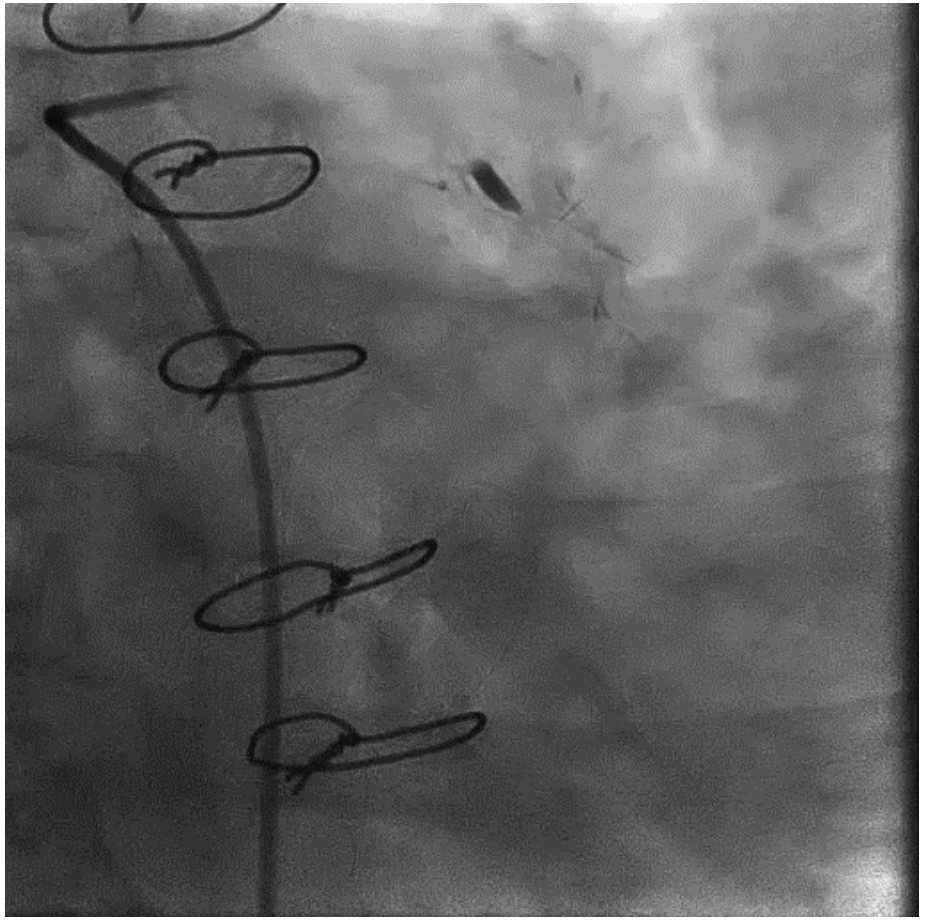


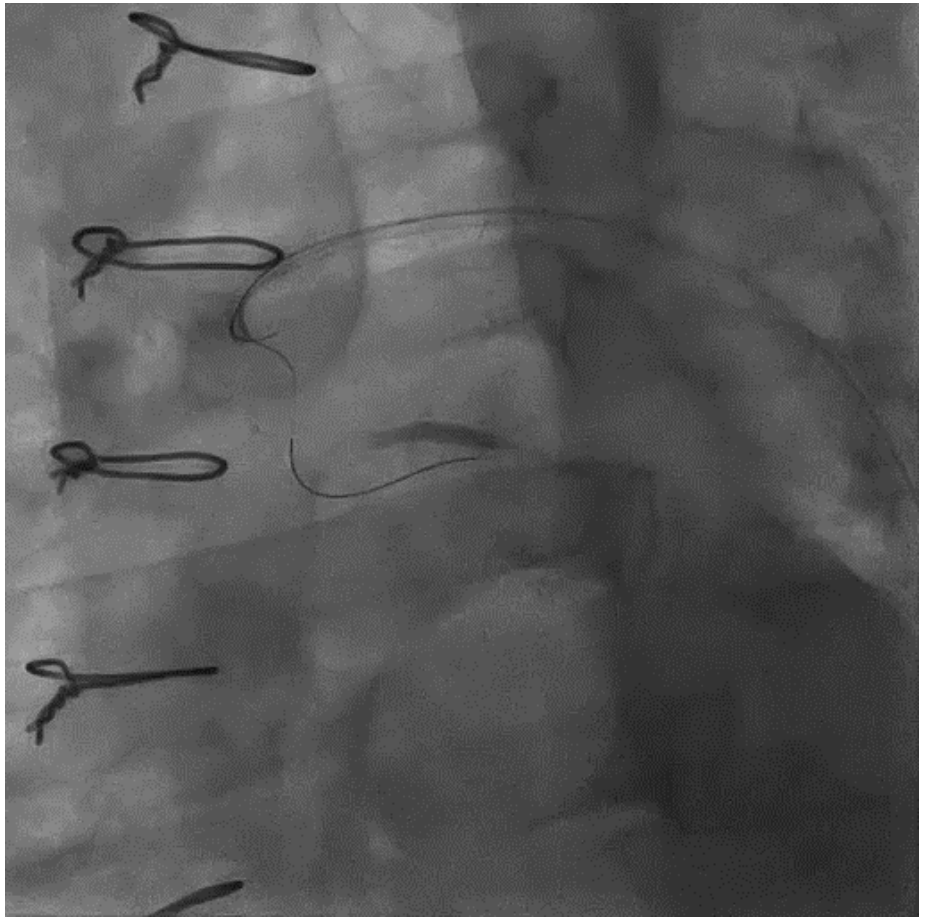




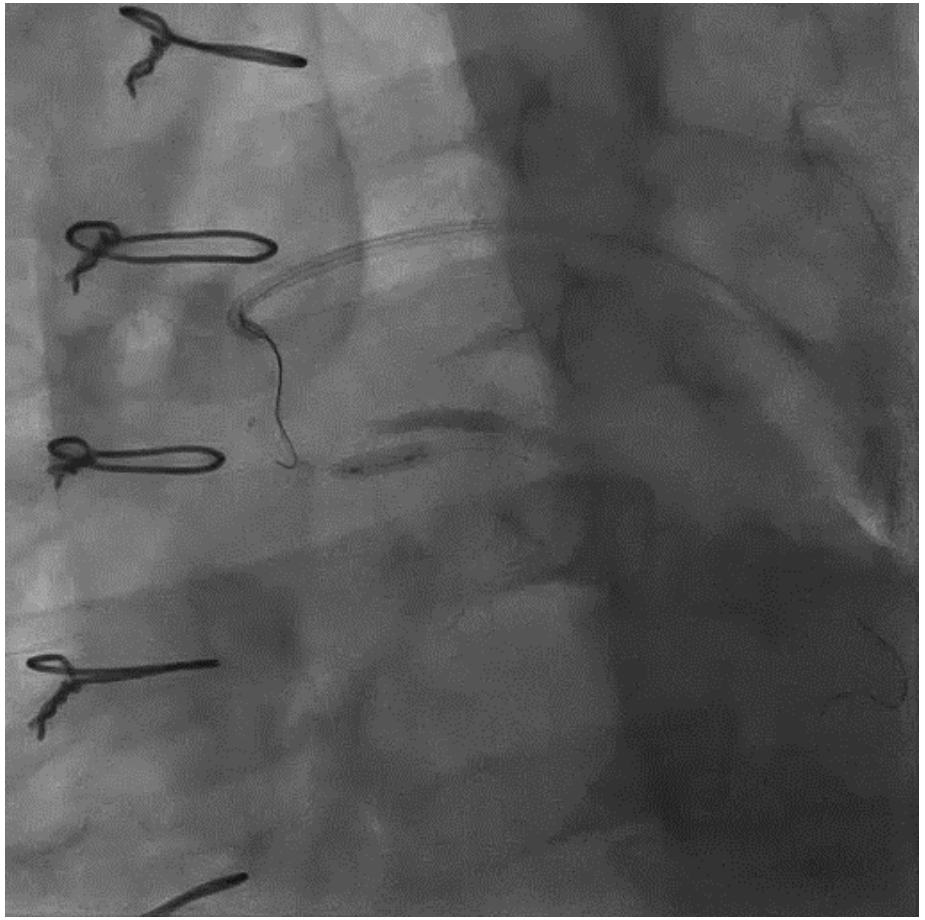
Case 4

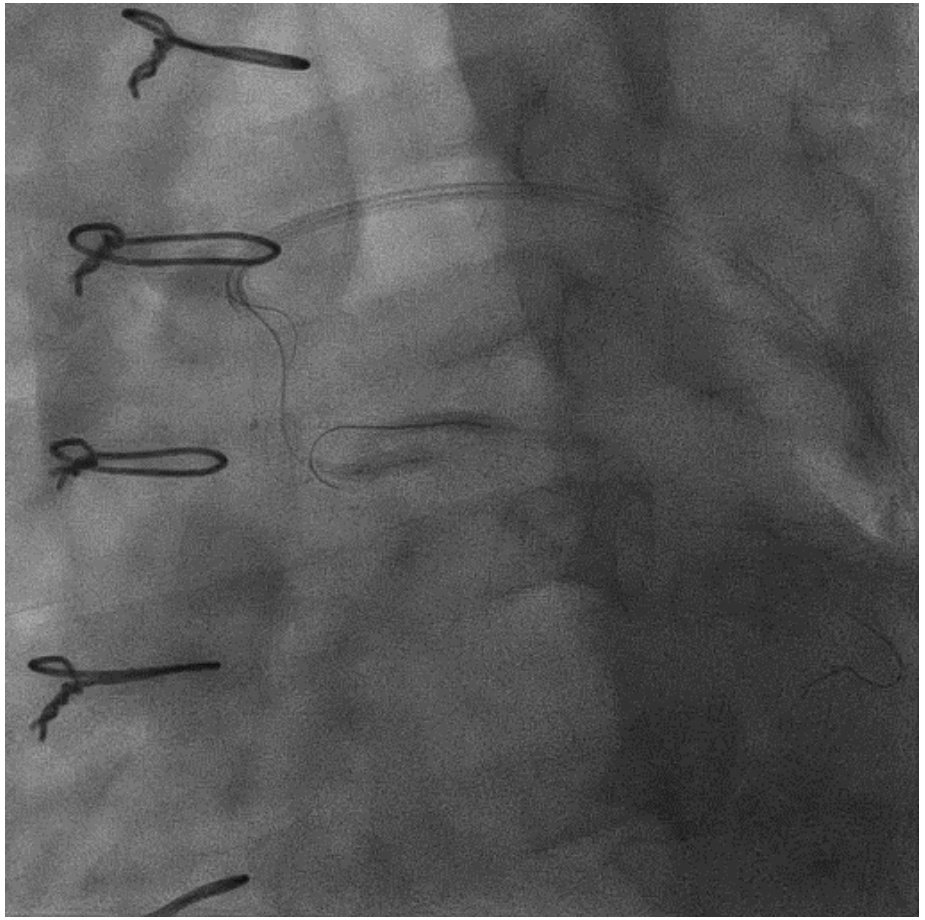


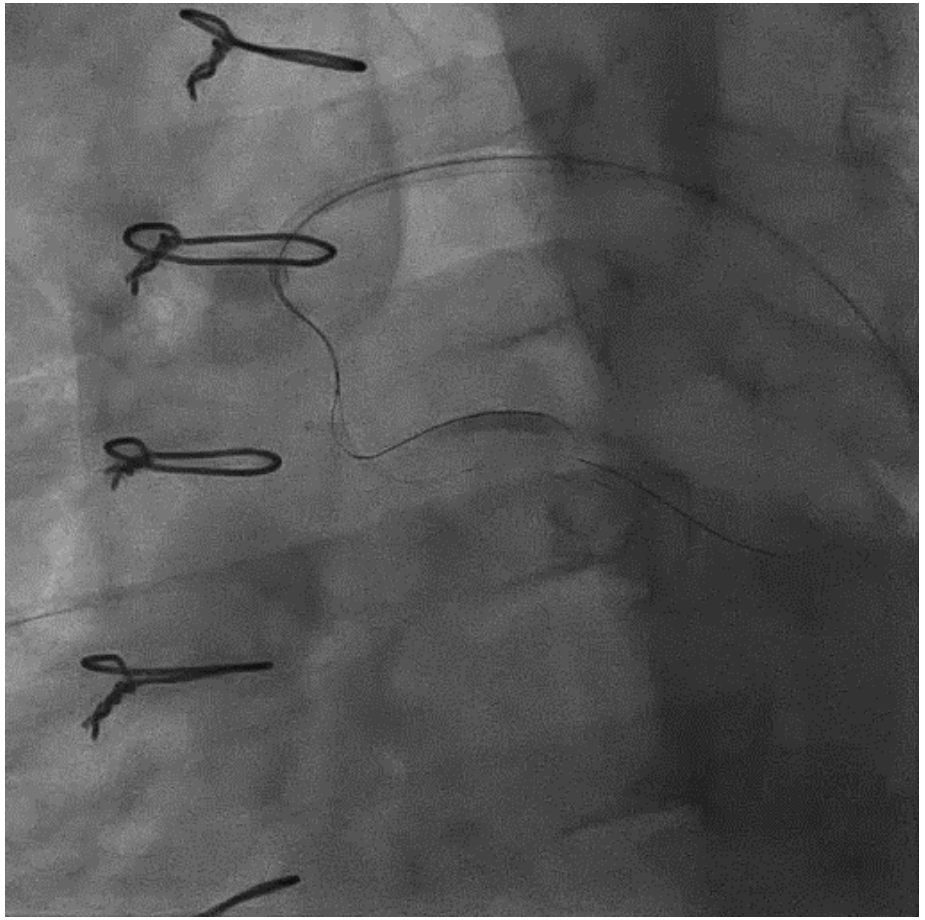


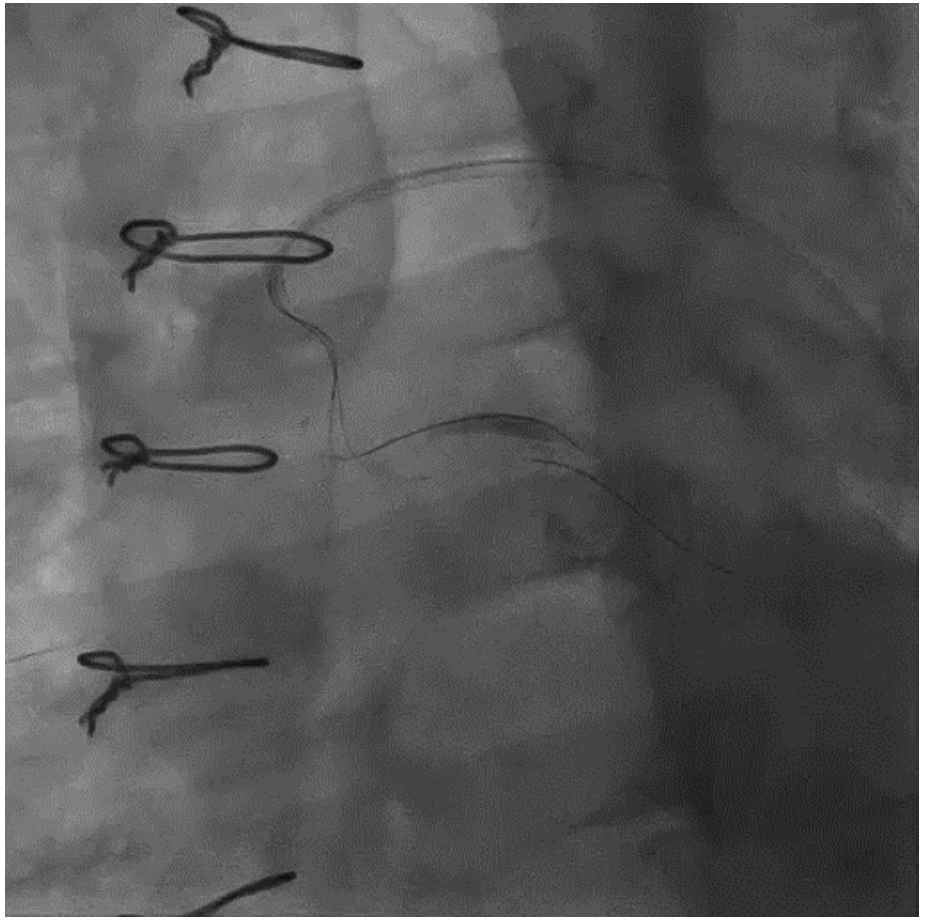


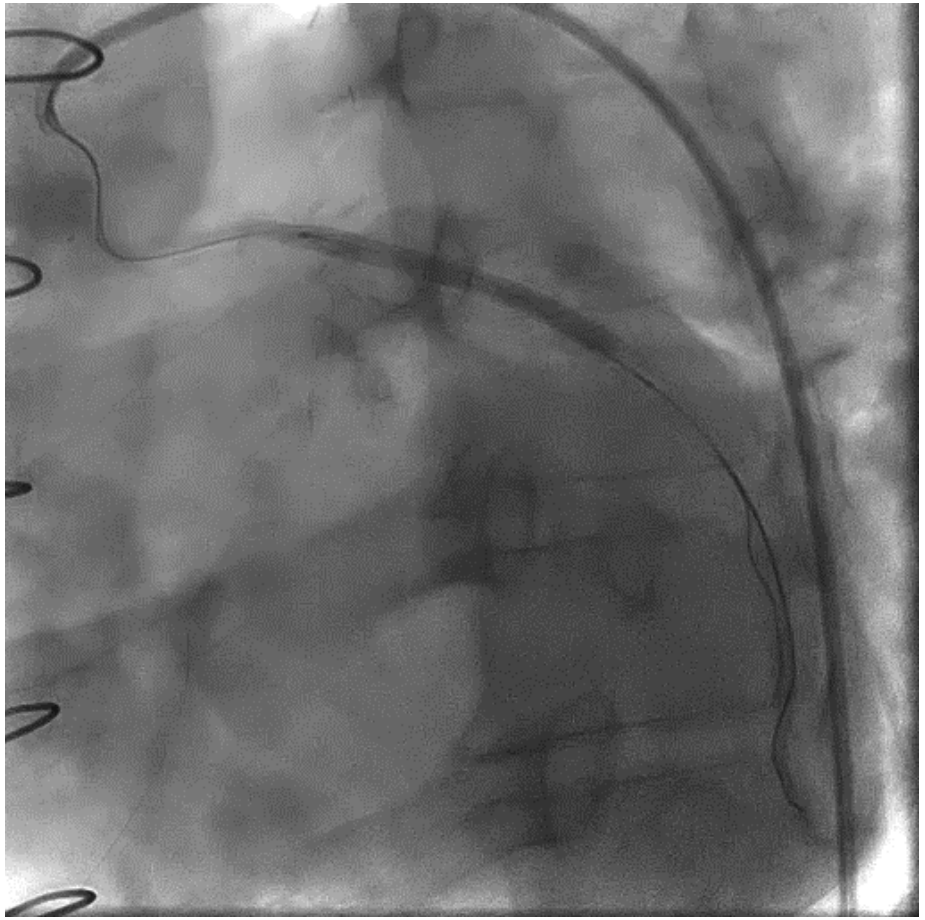
- What’s your plan?

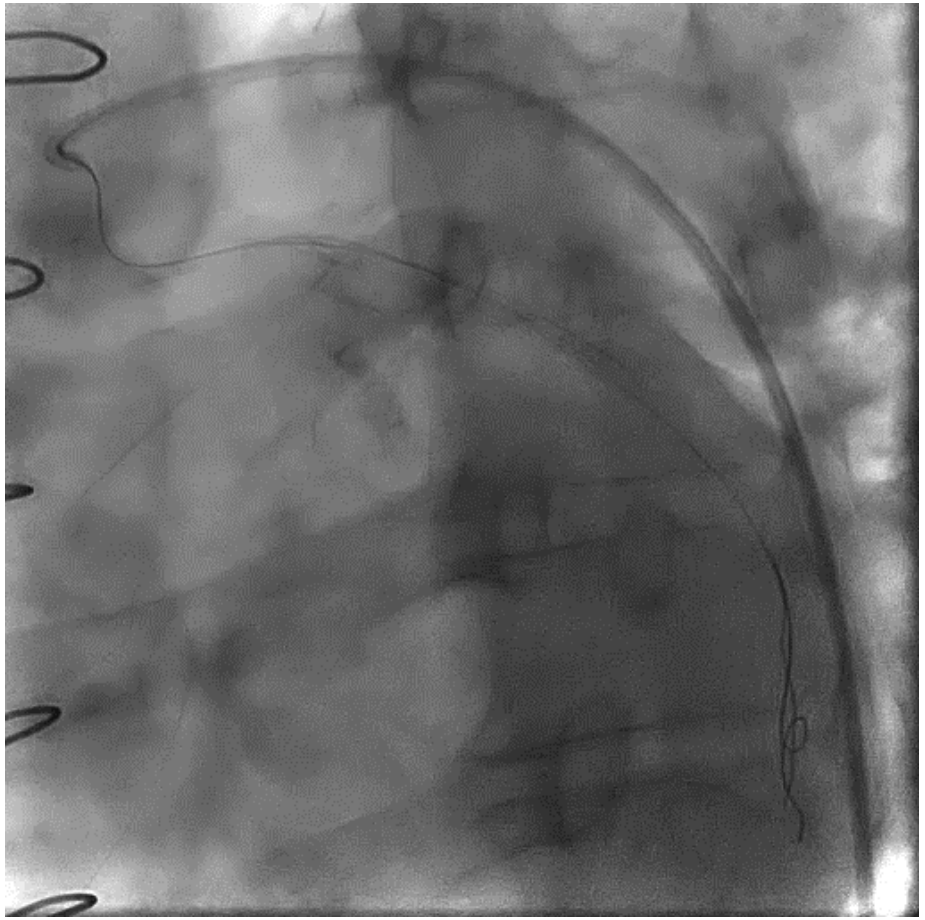












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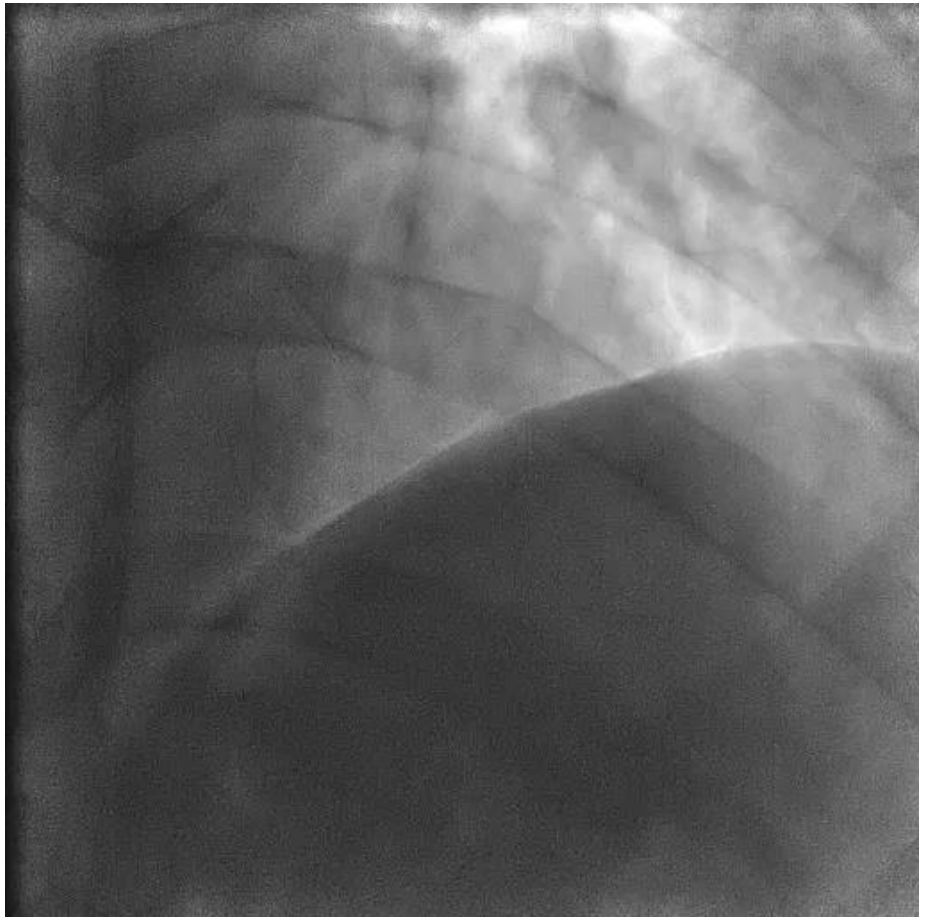
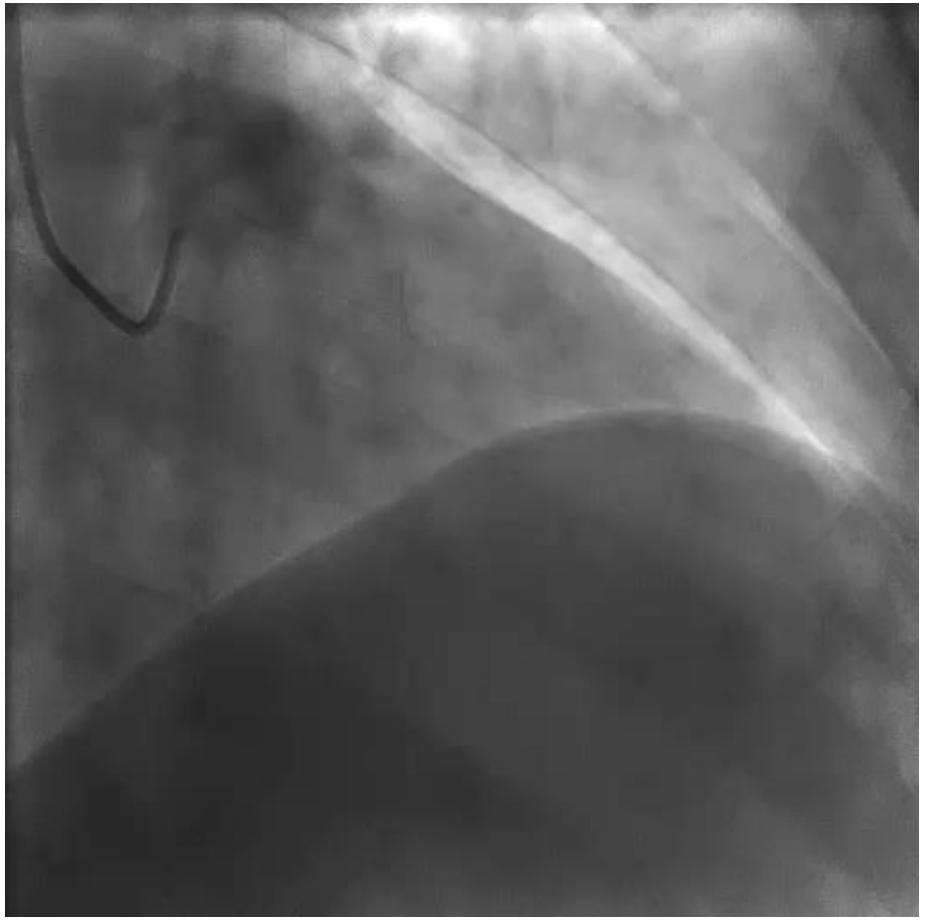
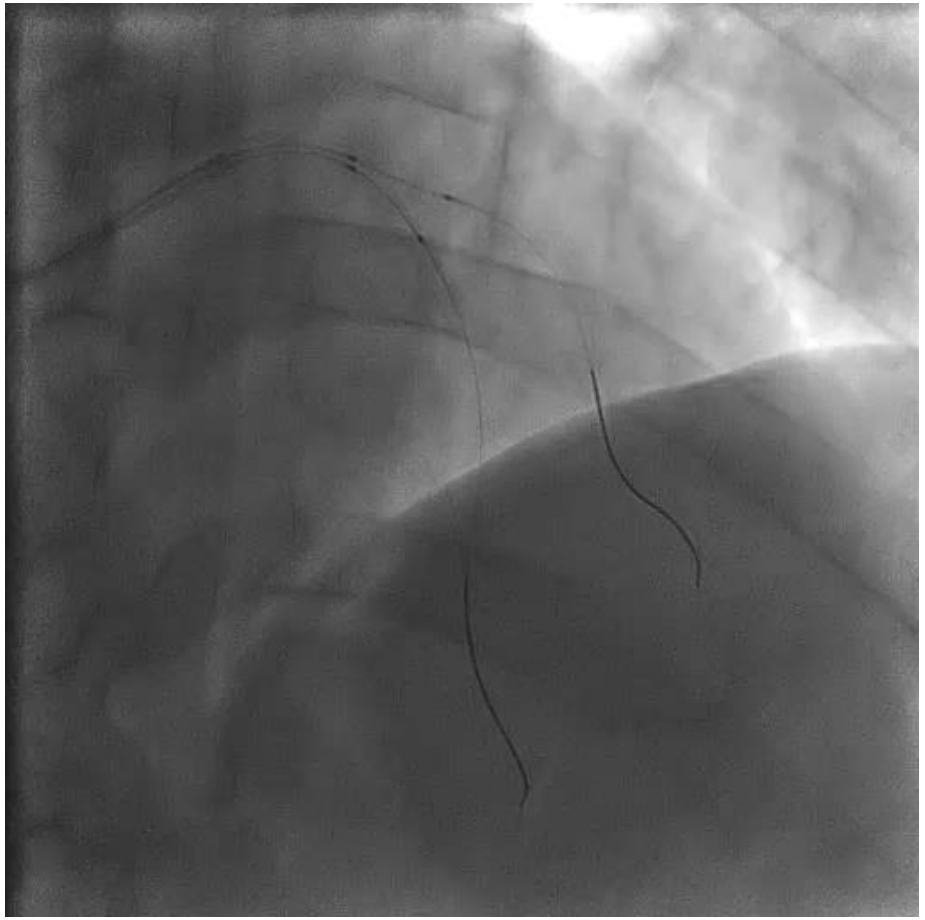
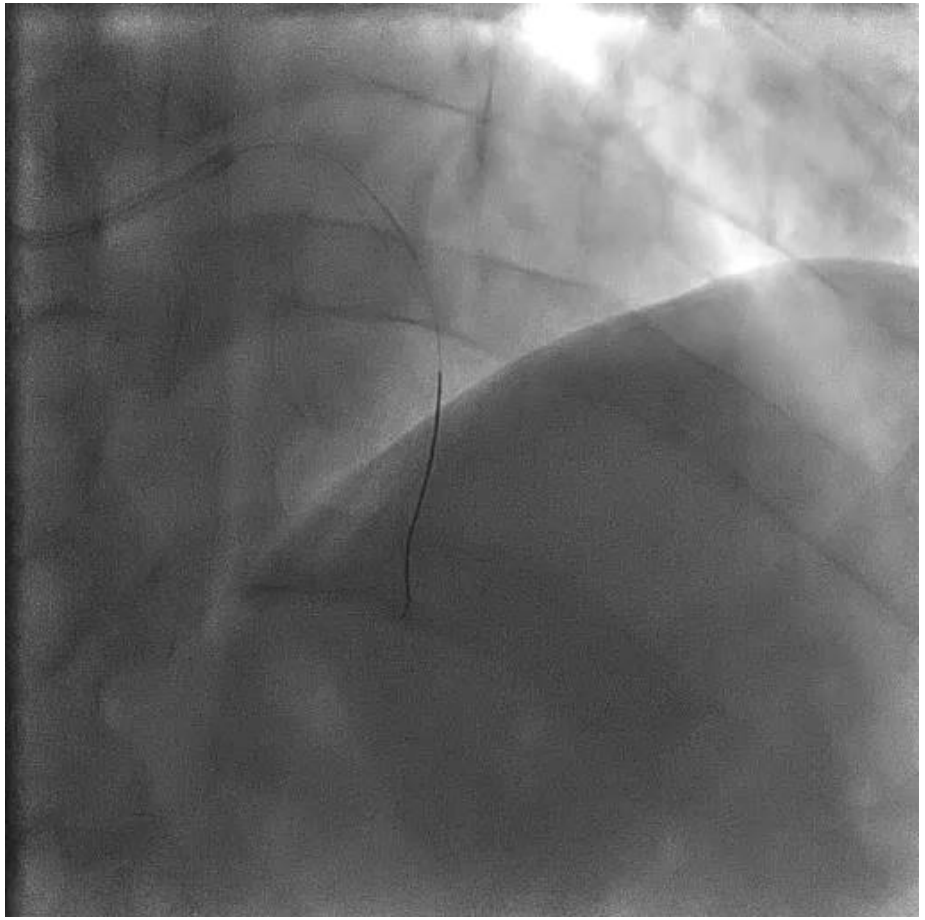




- What’s your plan?

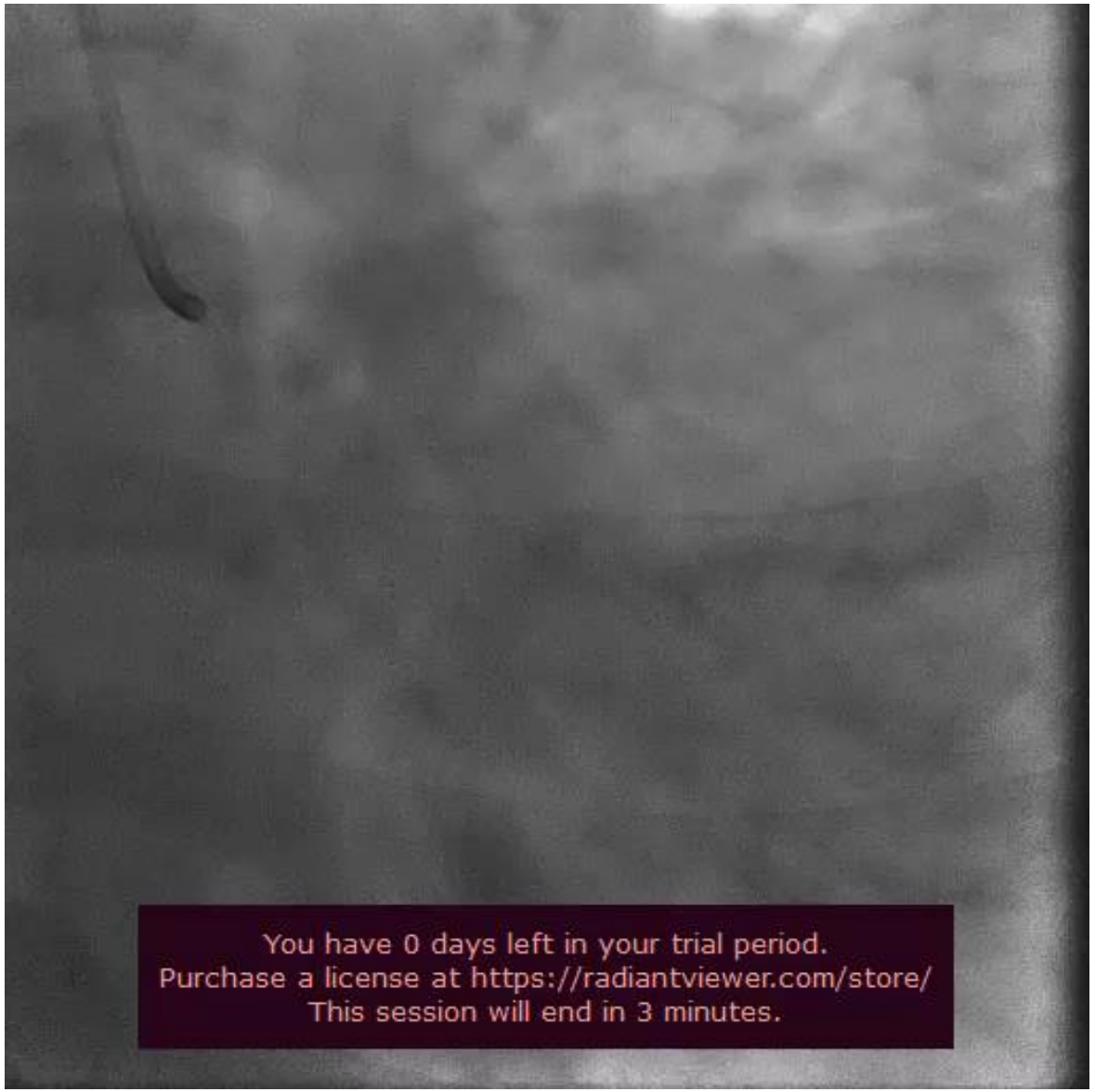




Case 6

- 58 years old woman presented with UA
- The surgeon refused CABG, because the patient was obese and had severe COPD

- Echo: LVEF:50%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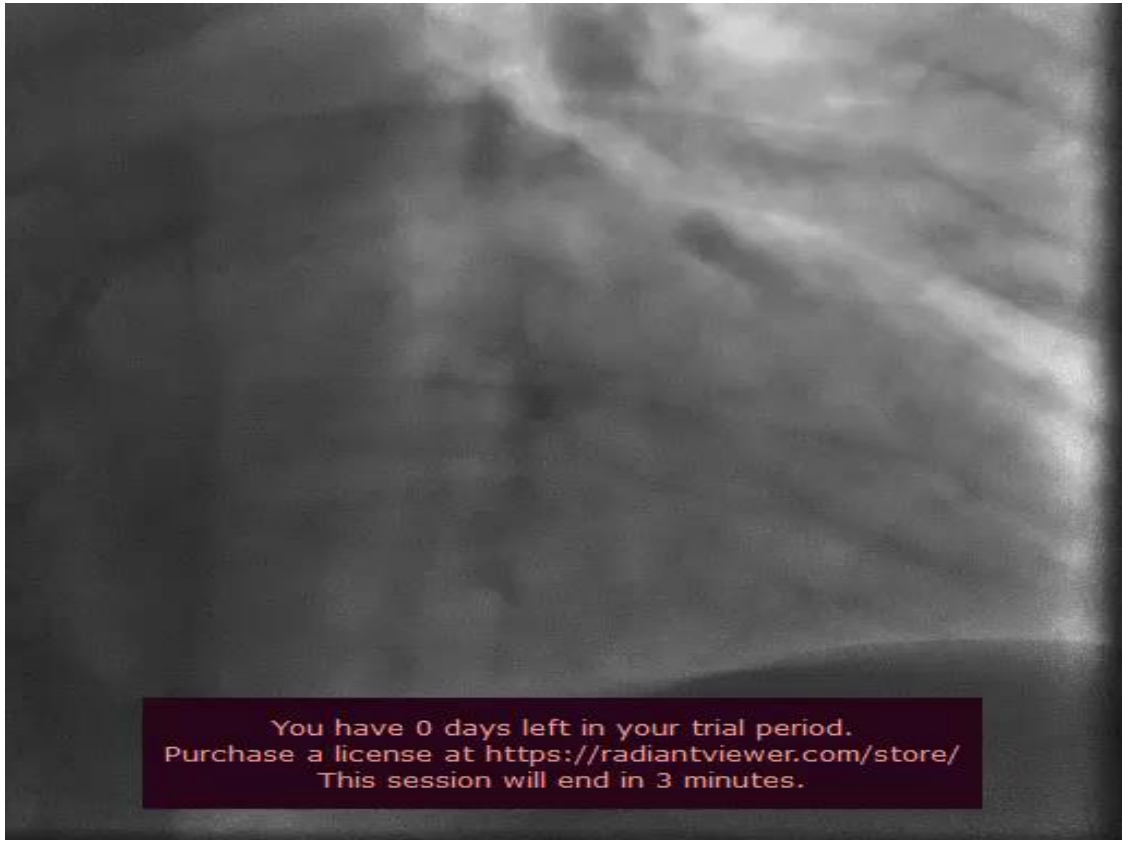
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- What is your plan for LAD-D ??

- A) Provisional Stenting
- B) DK Cruch
- C) TAP
- D) Cloutte


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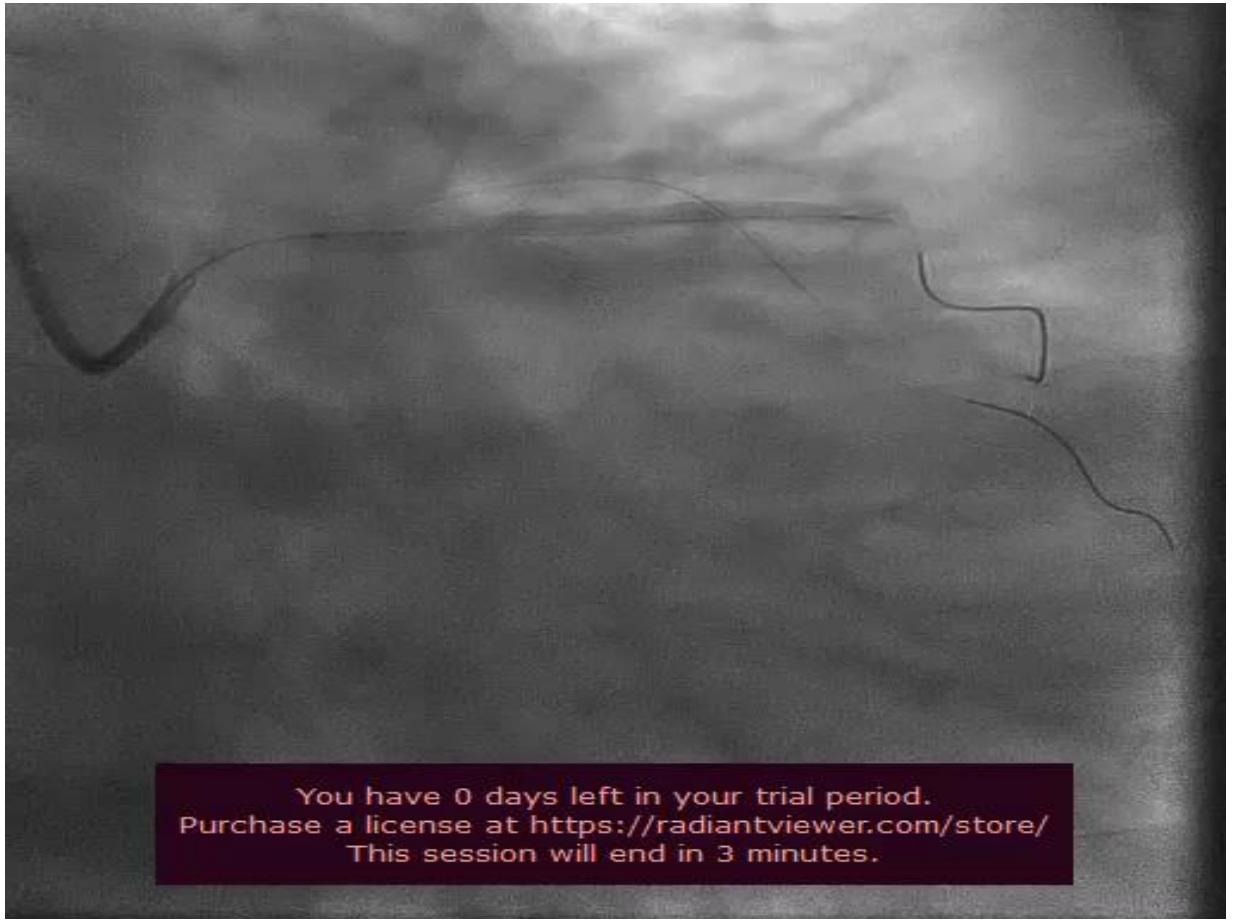
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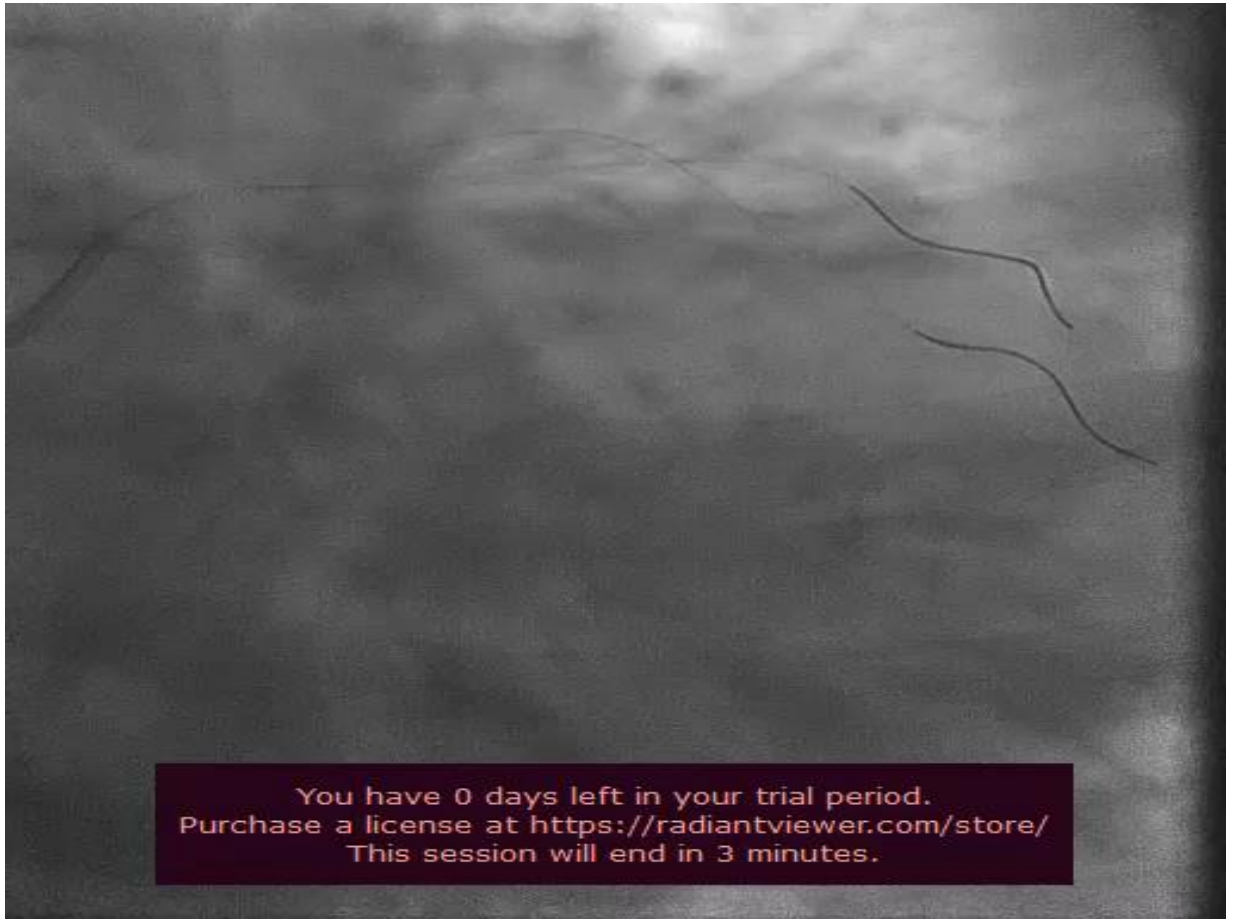
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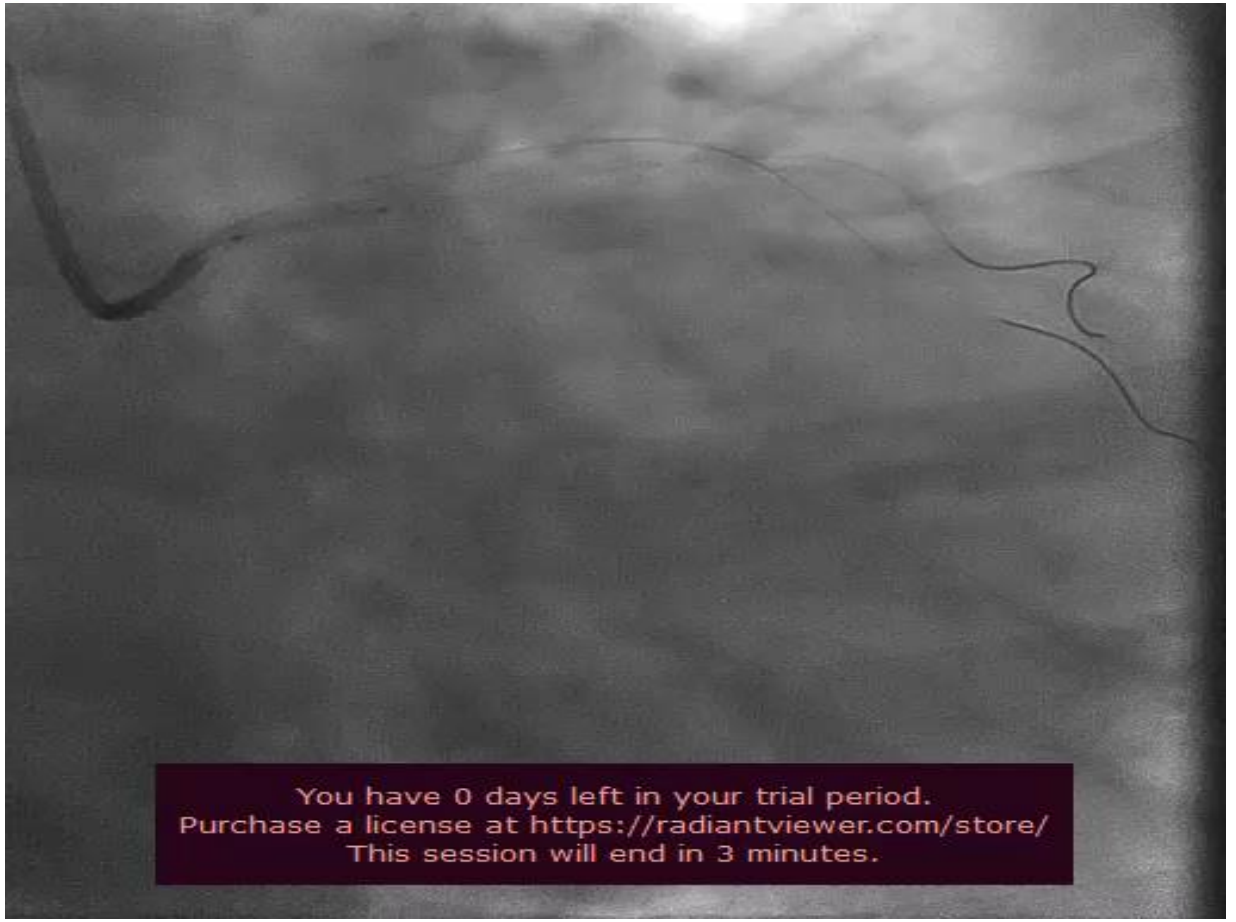
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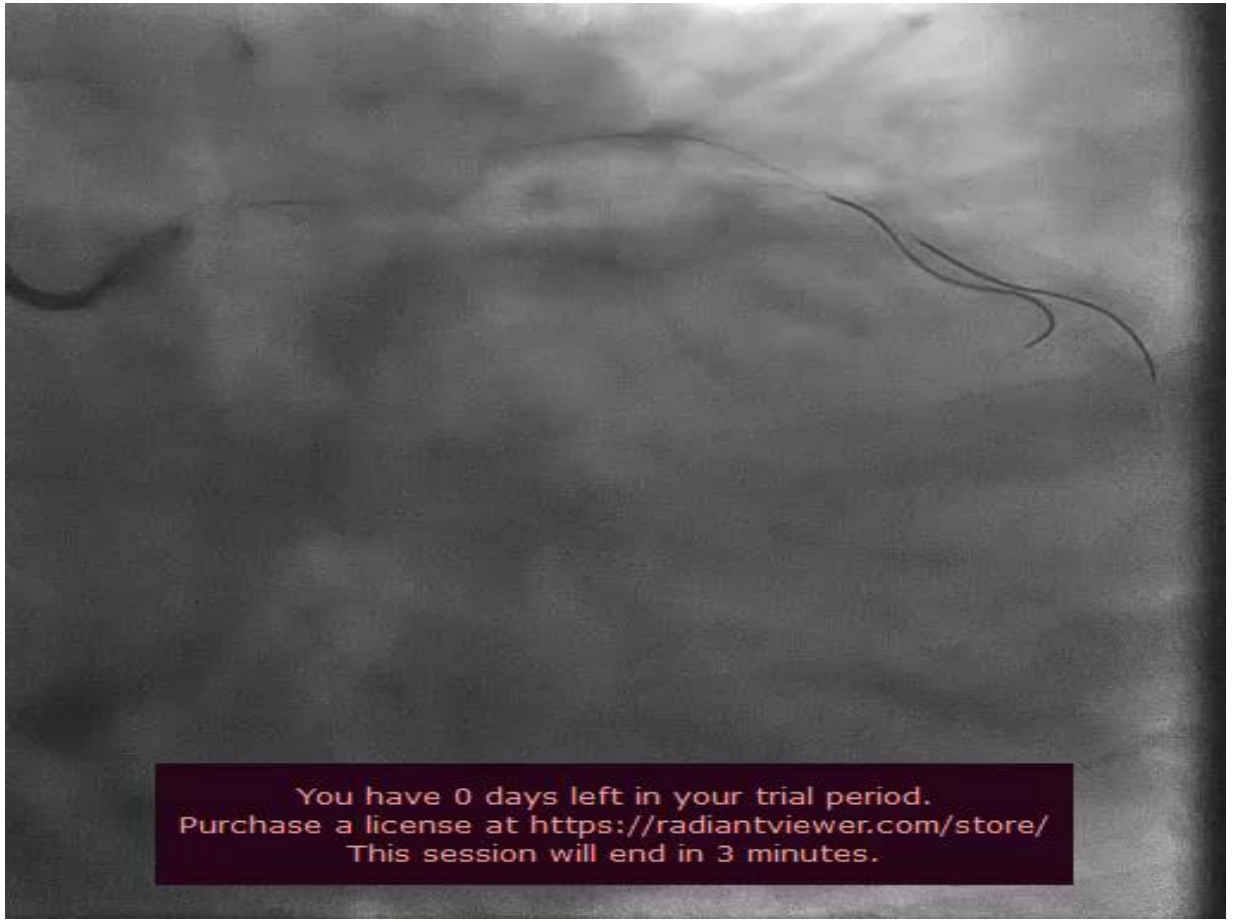
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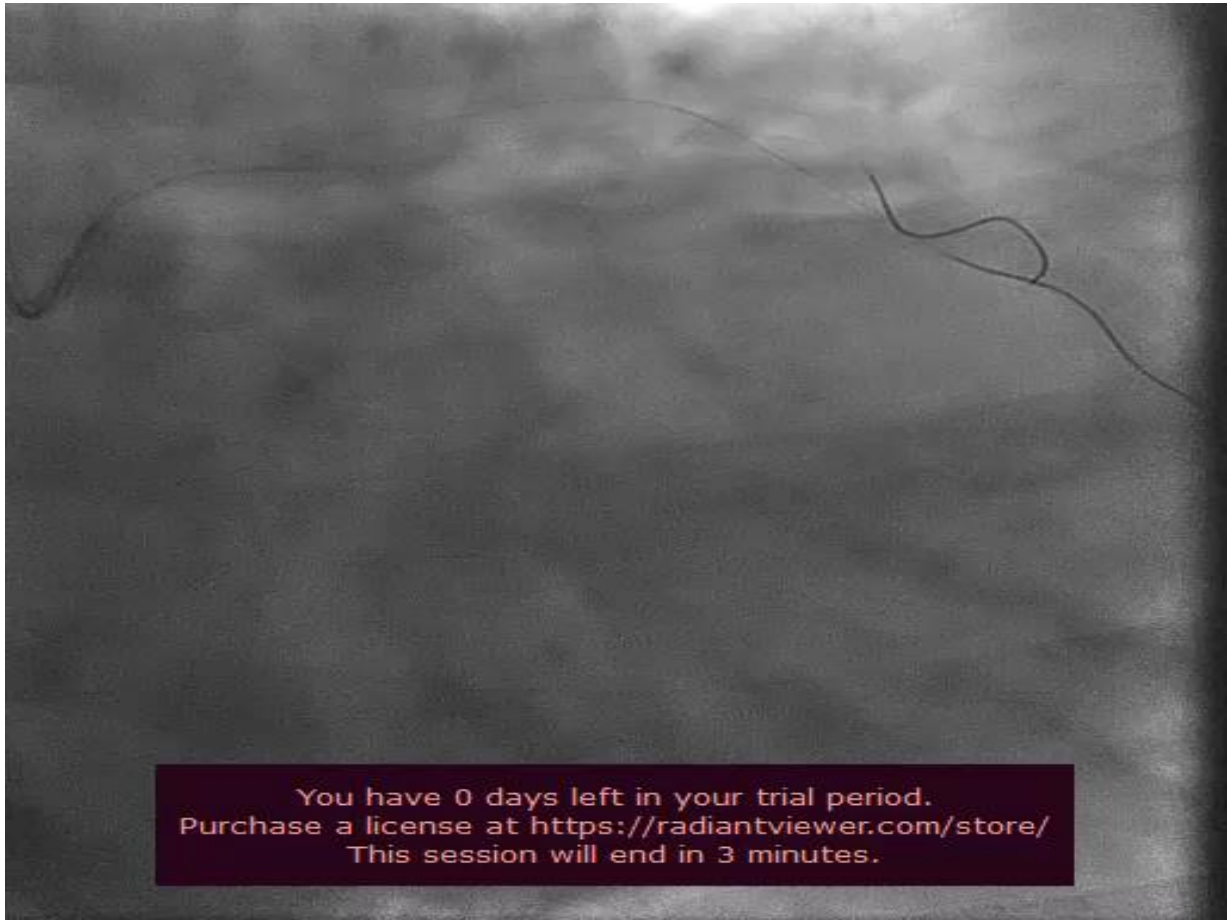
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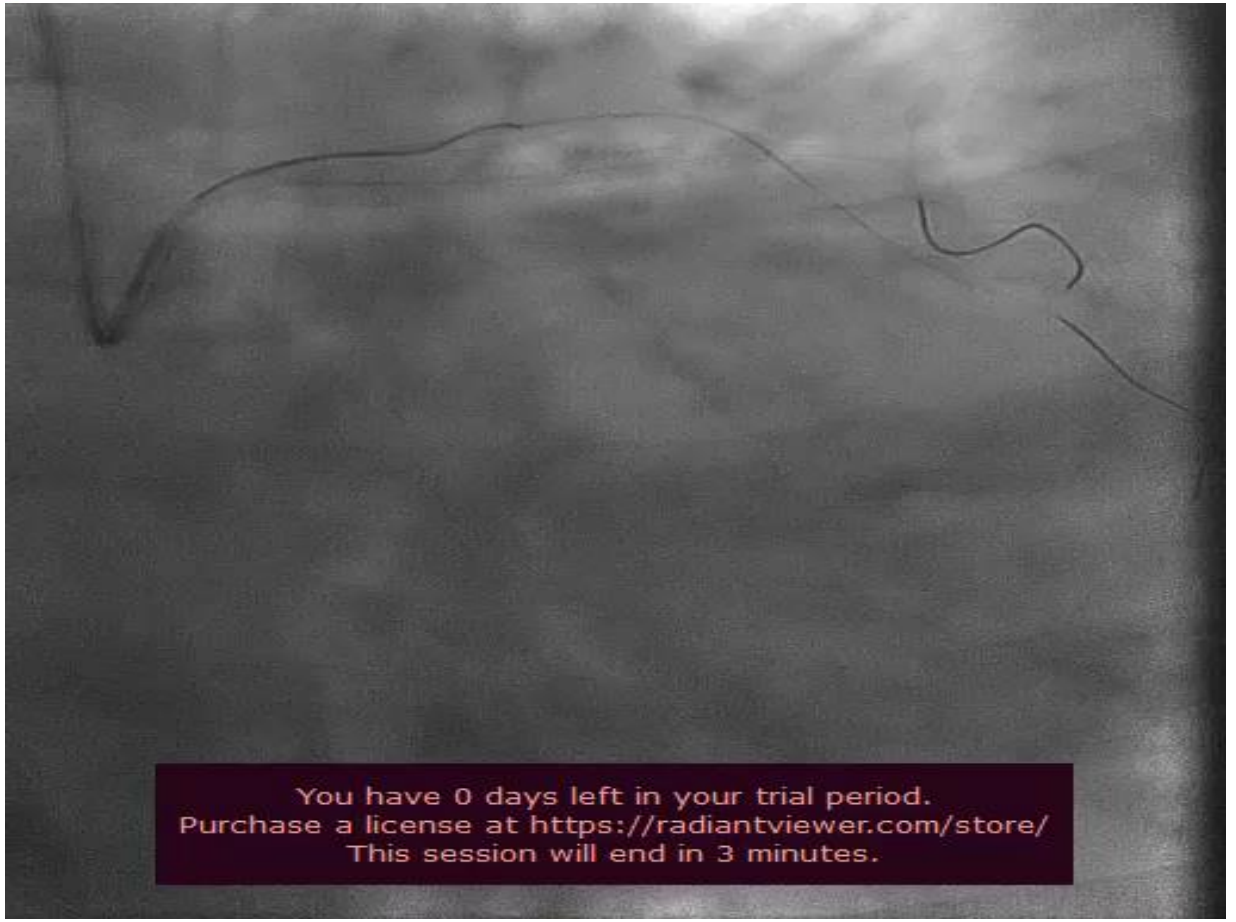
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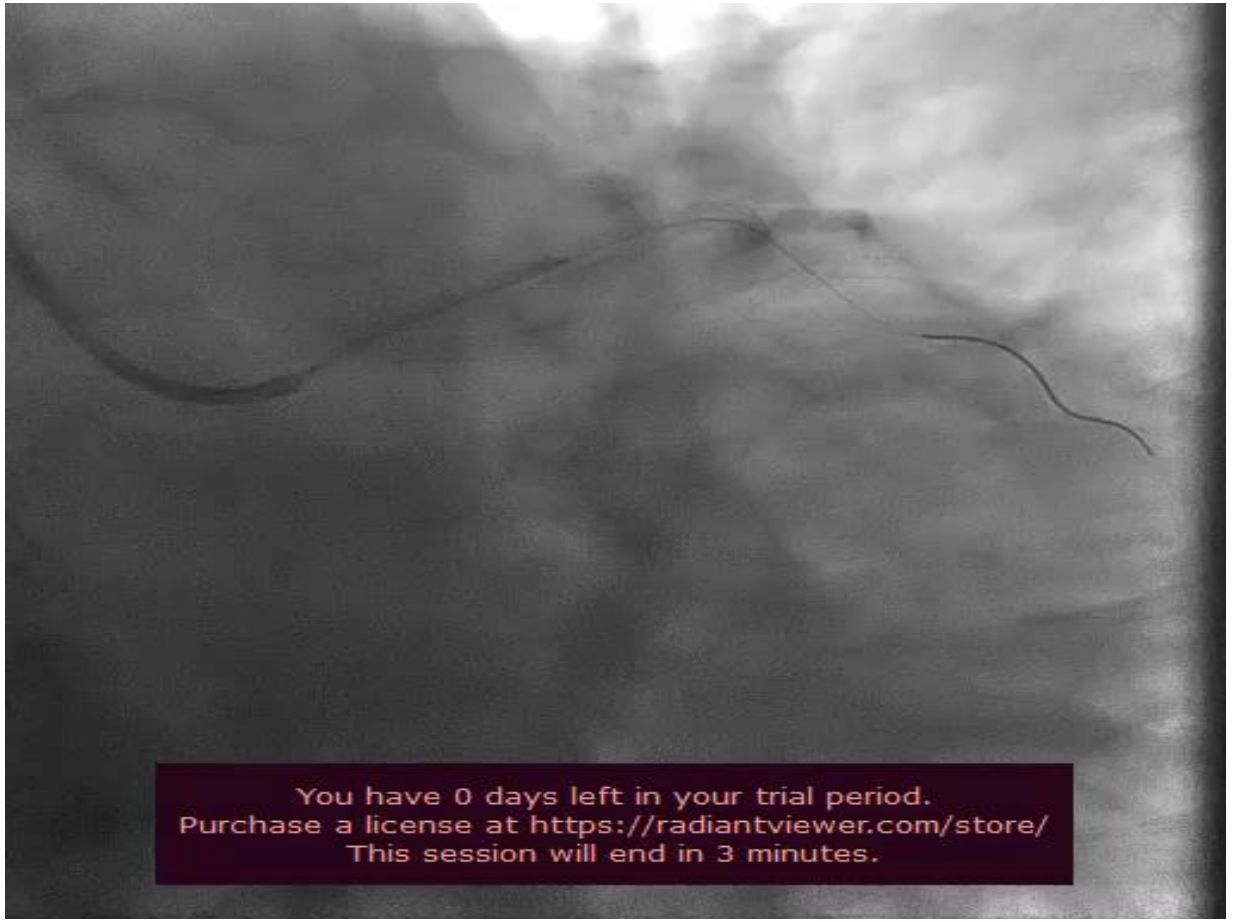
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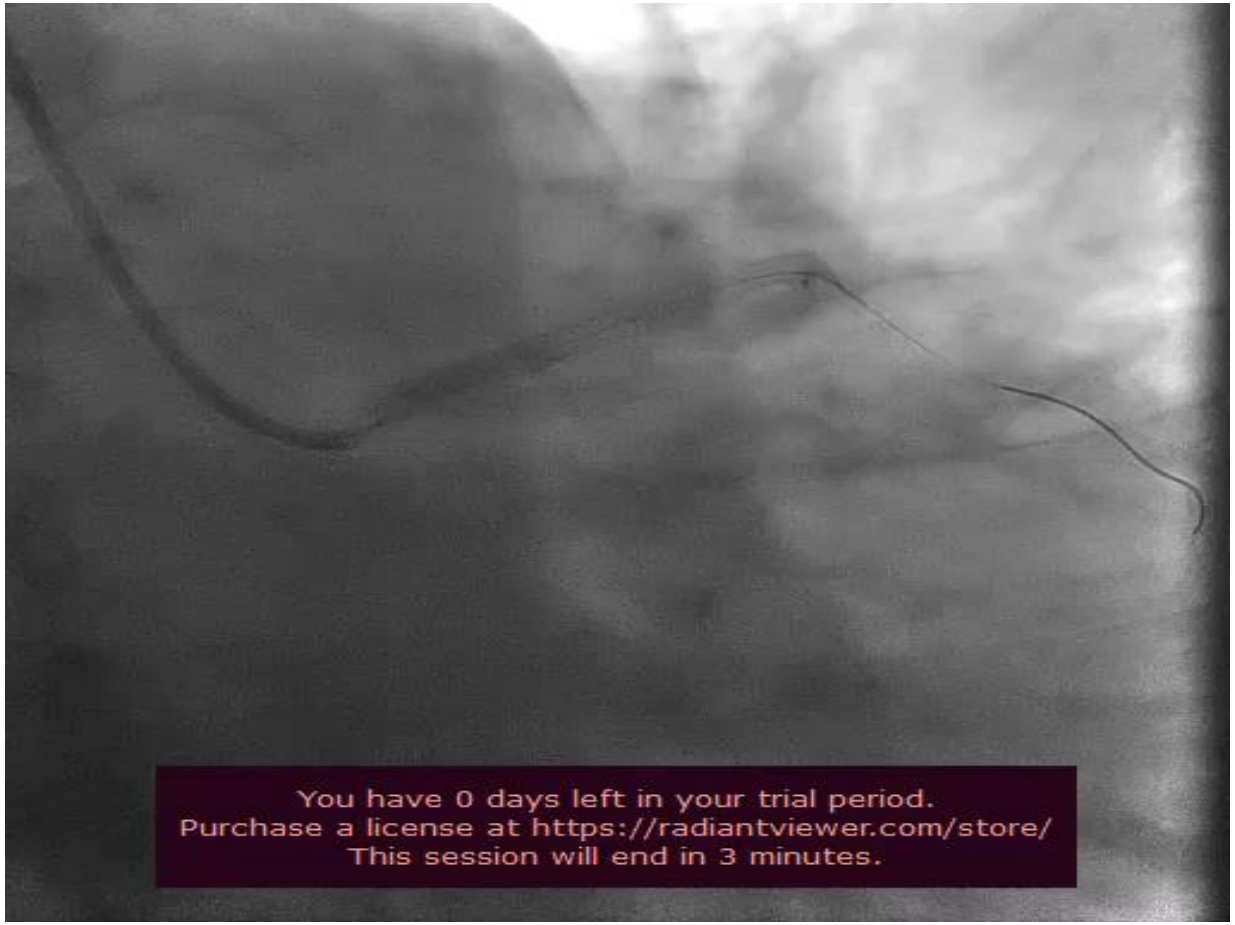
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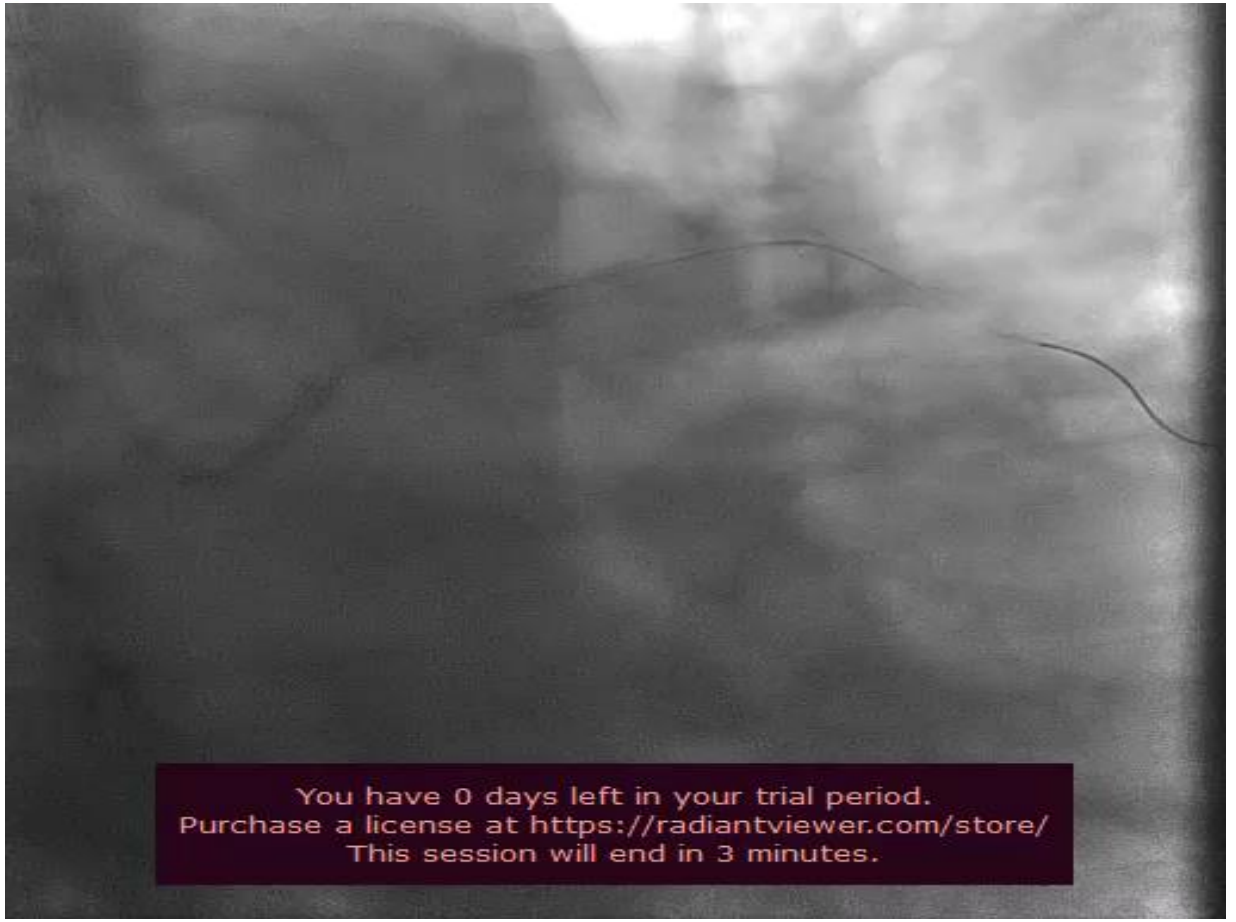
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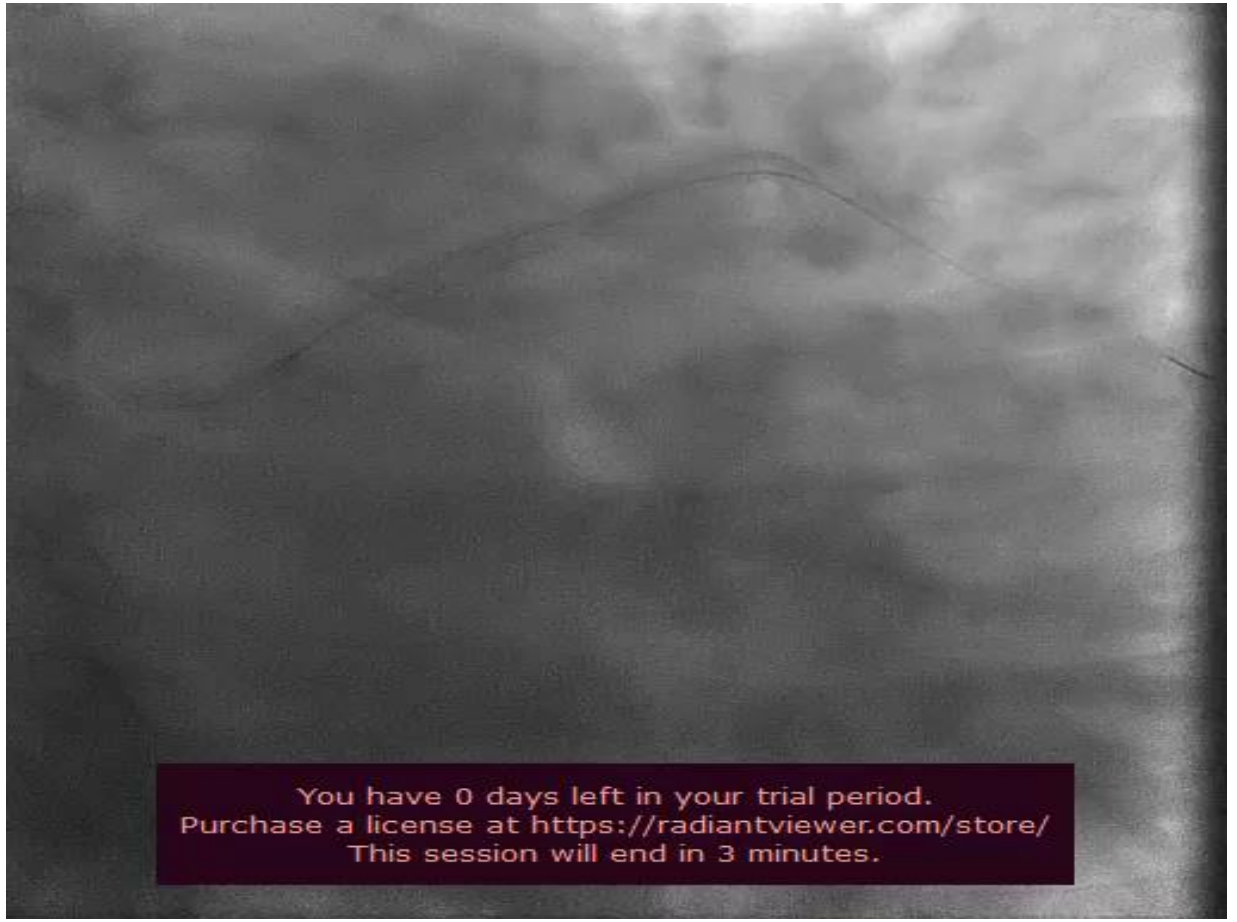
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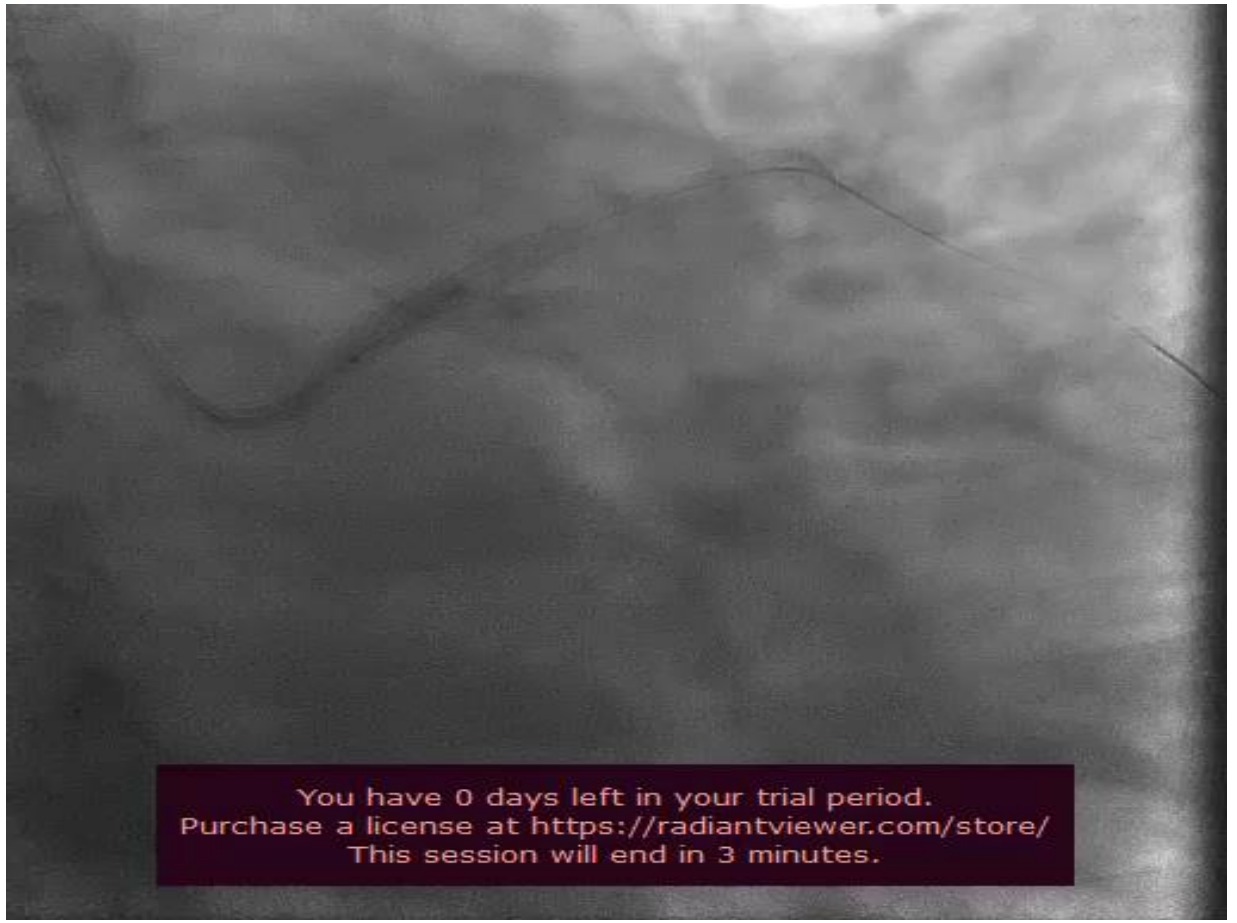
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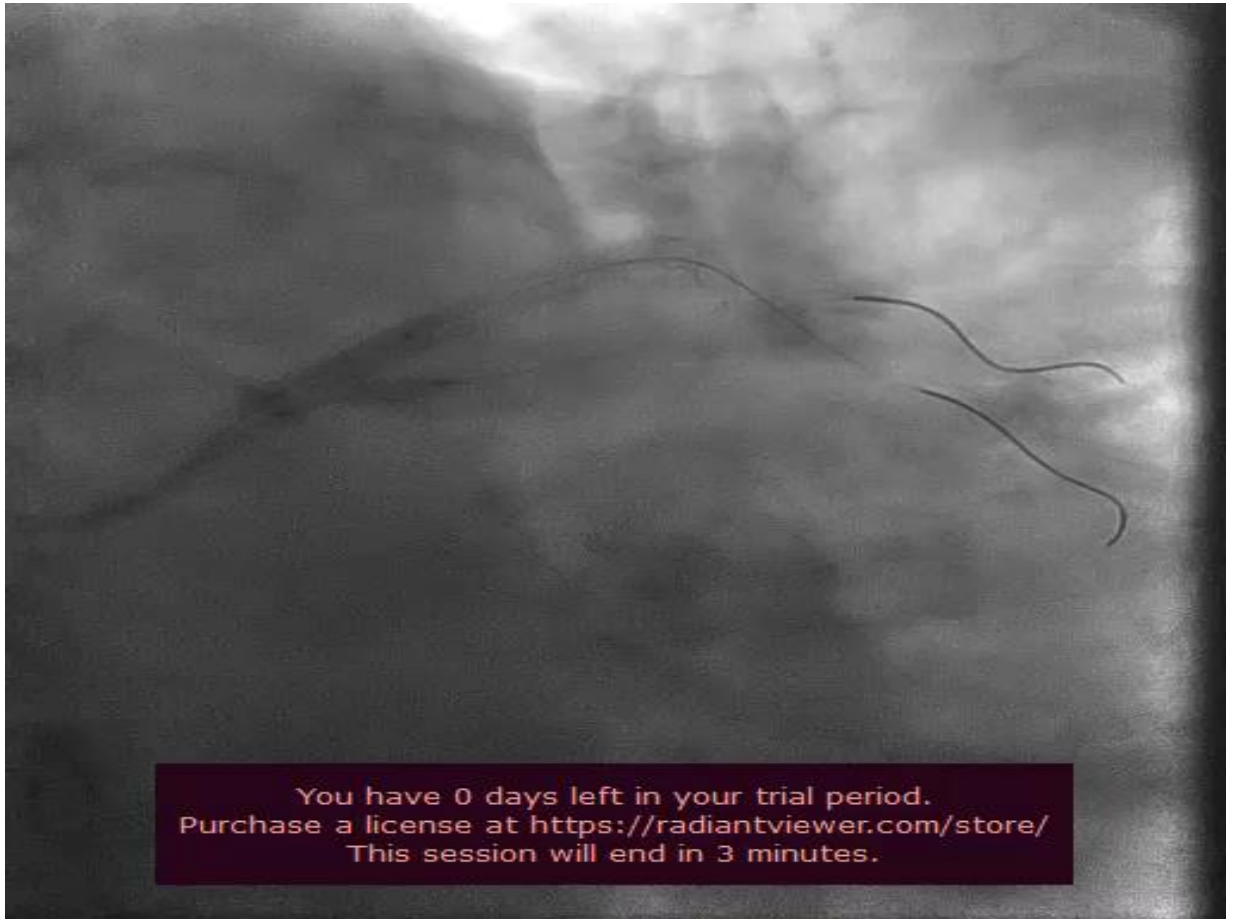
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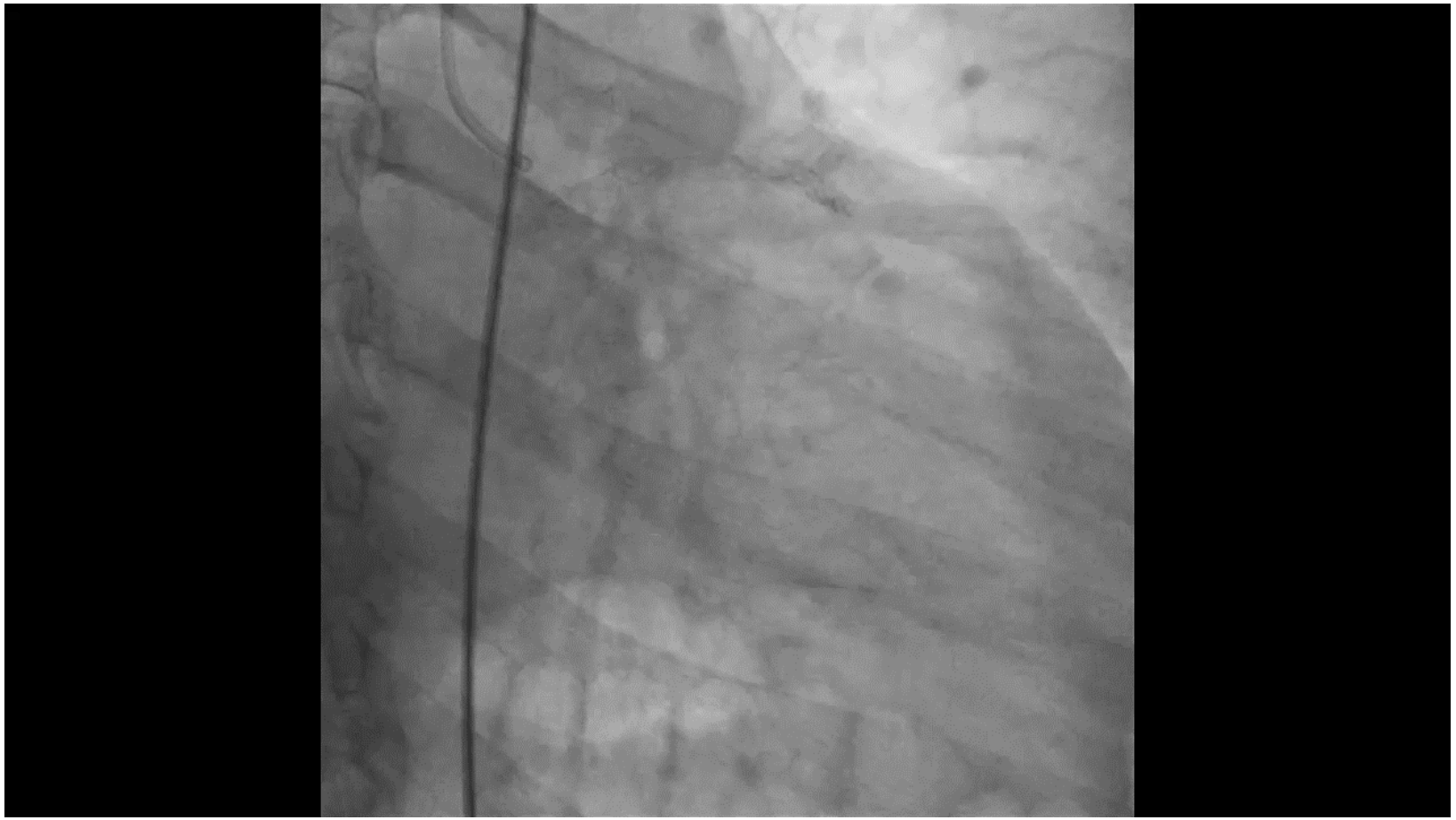
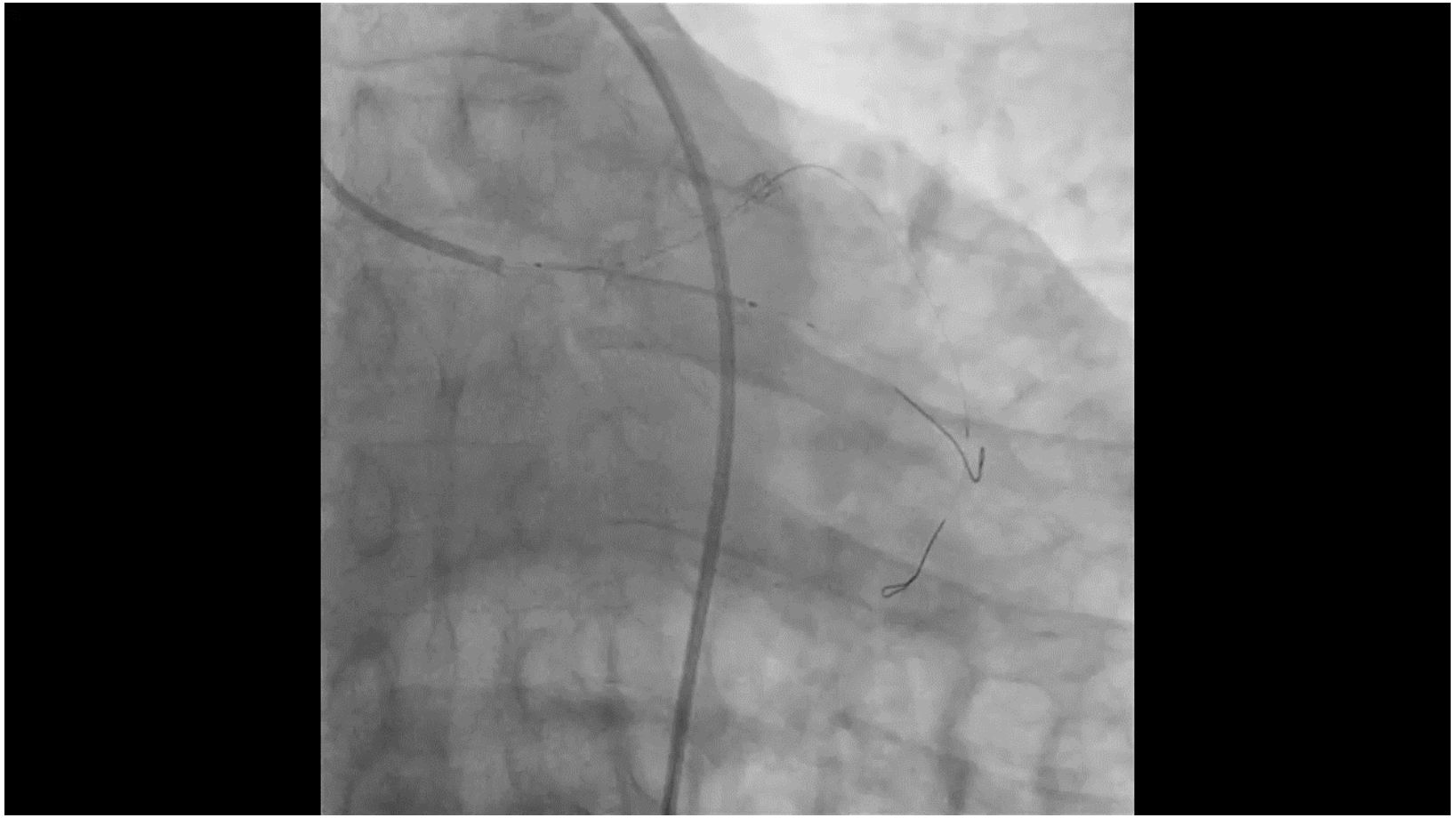
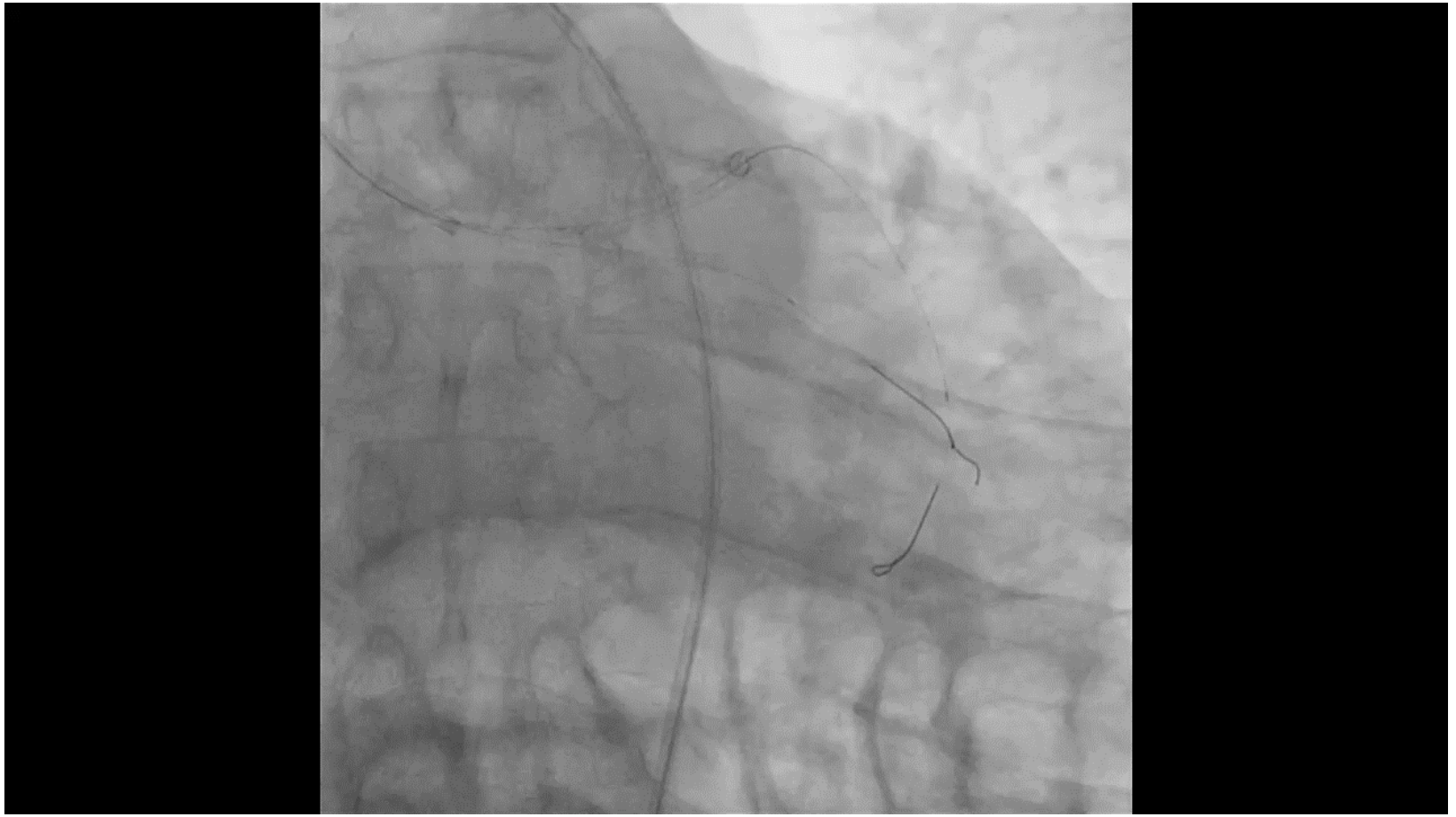
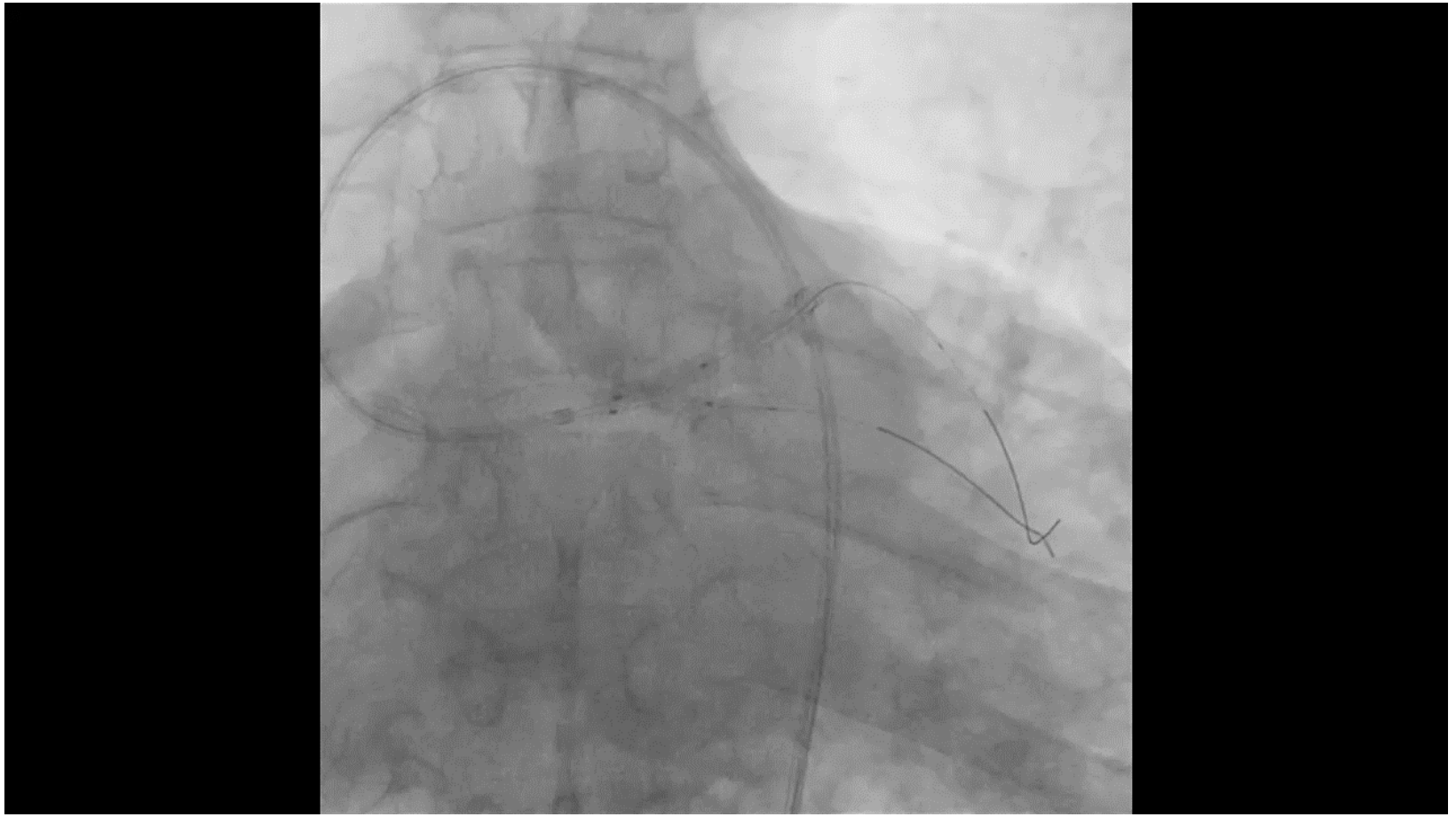
Case 7

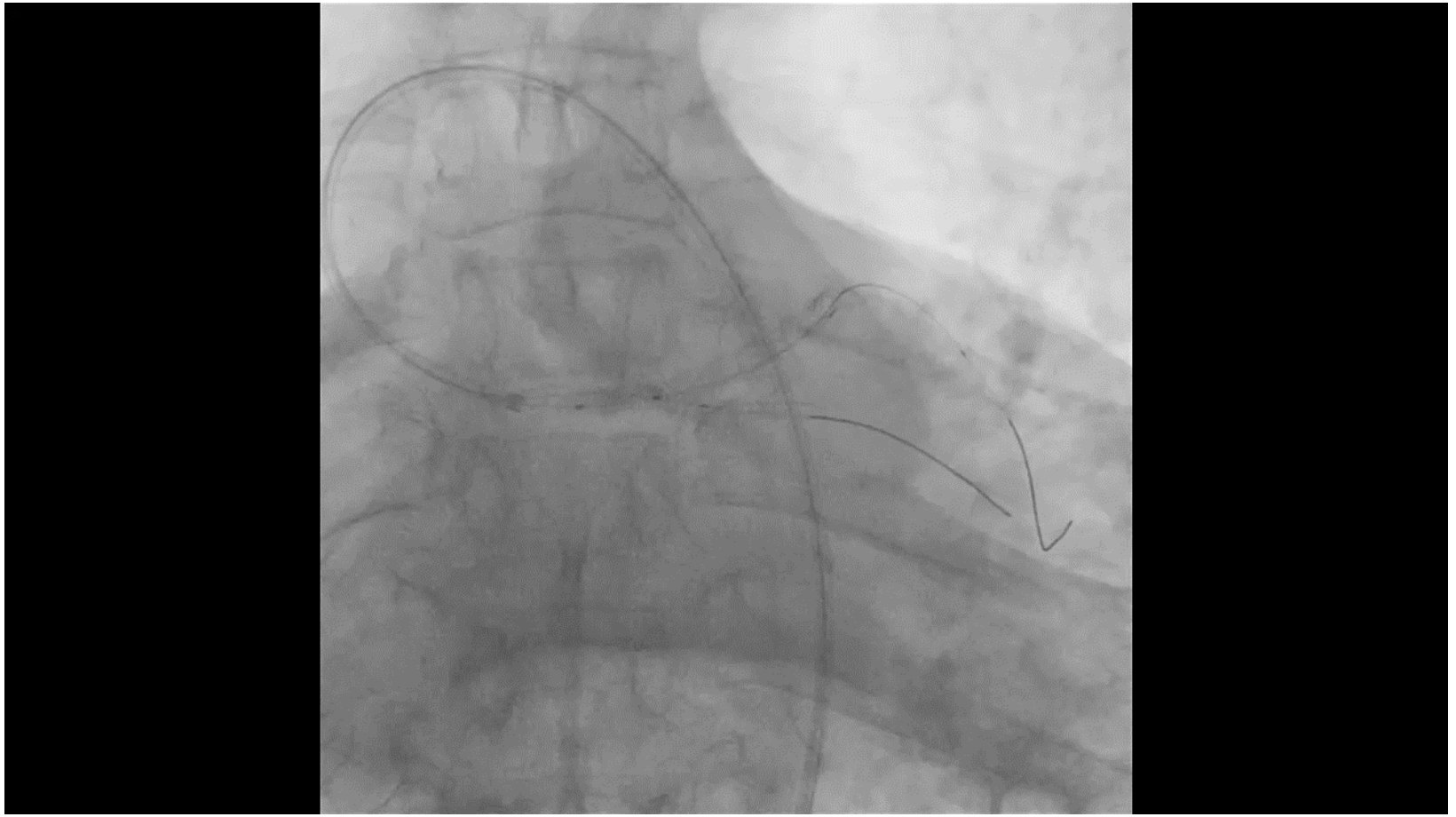


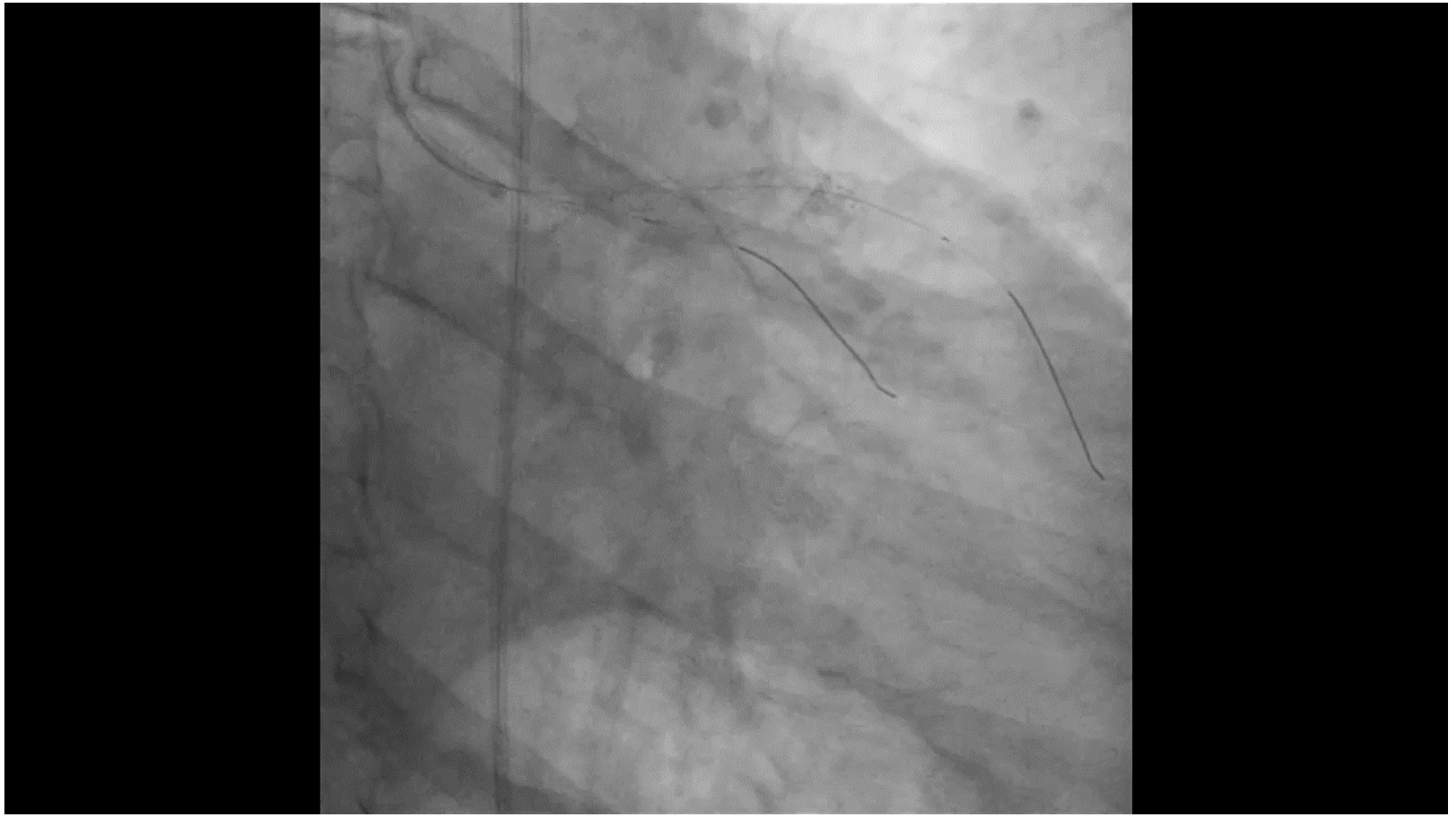
- What’s your plan?

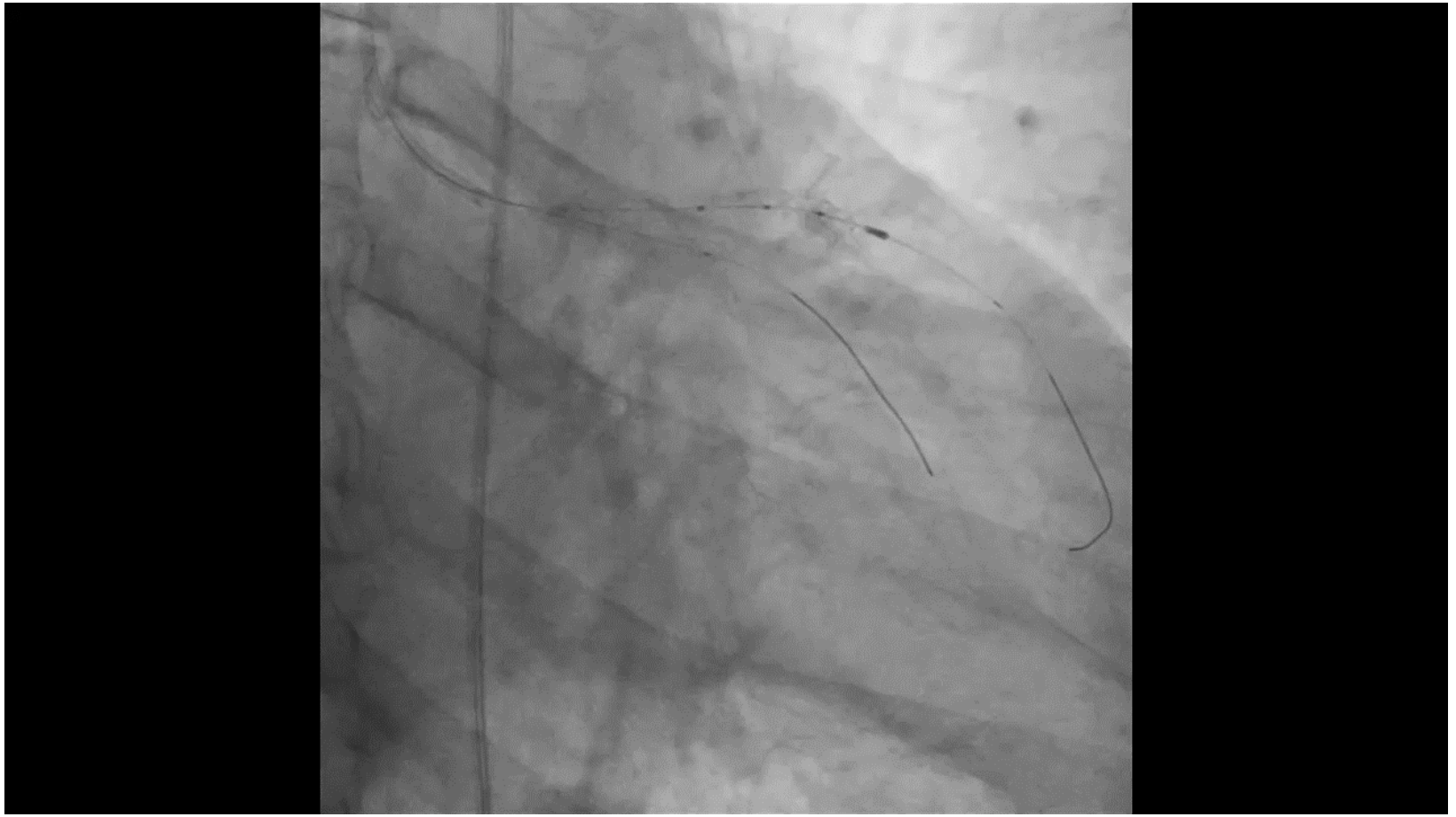












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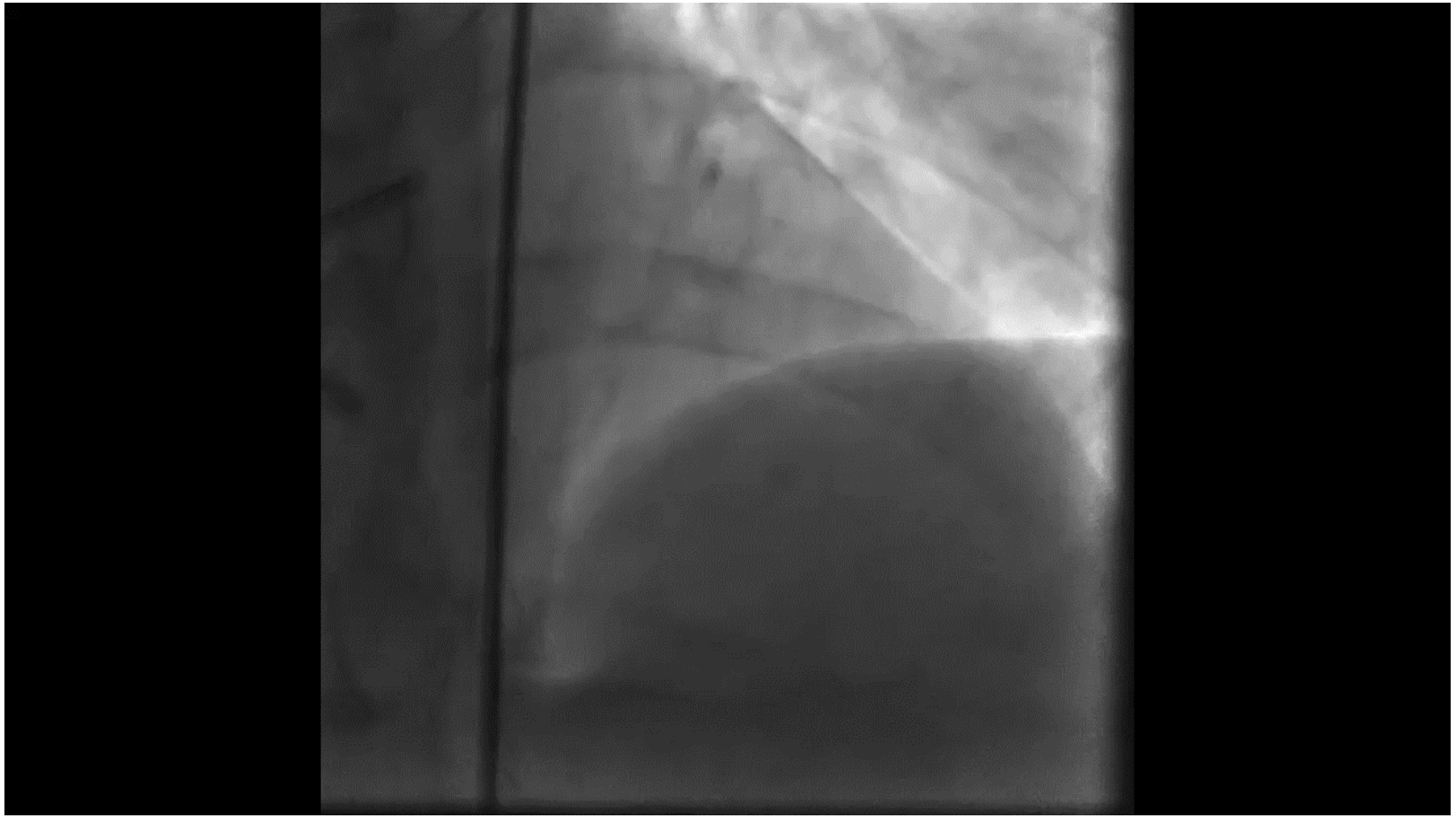
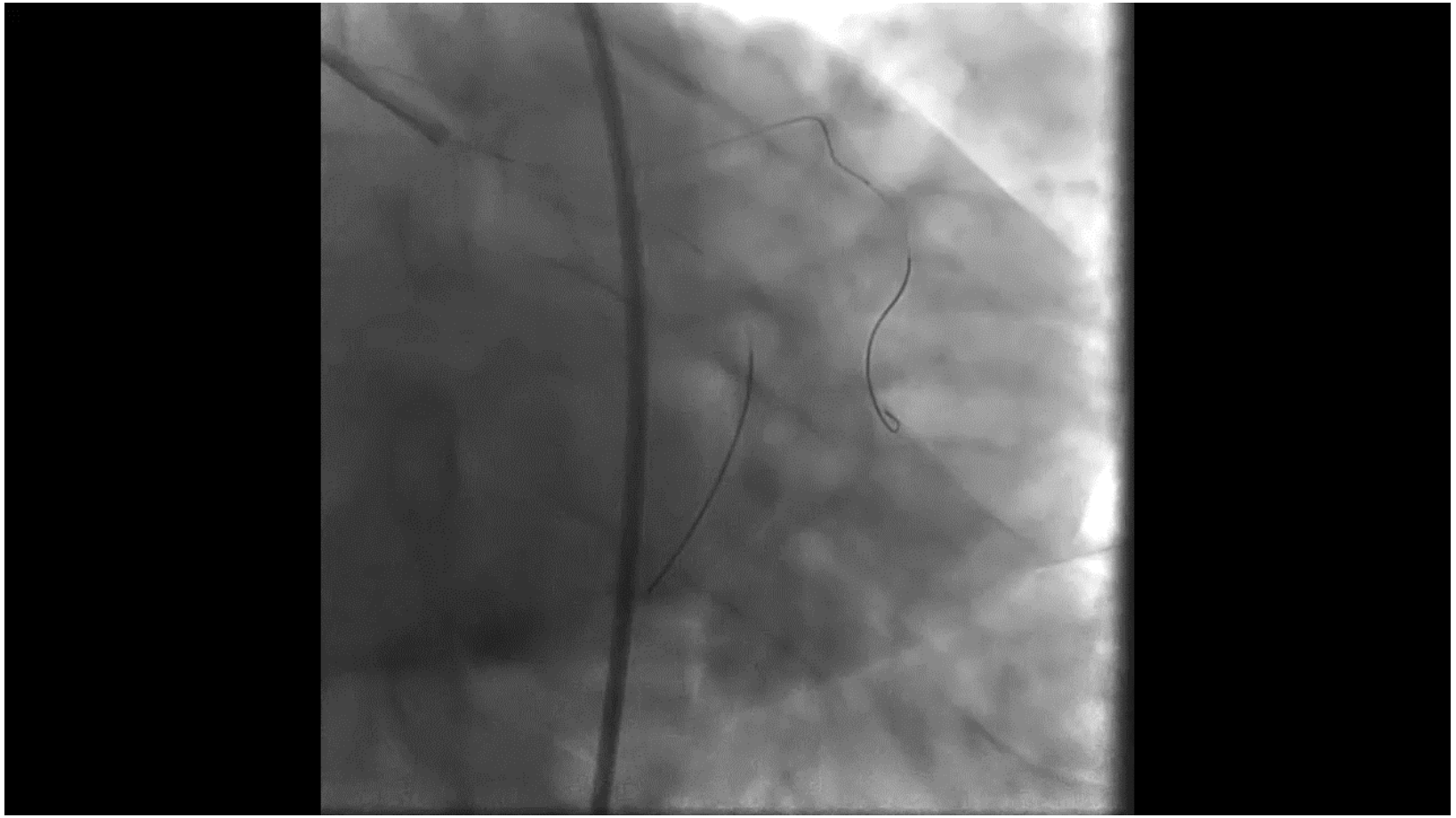
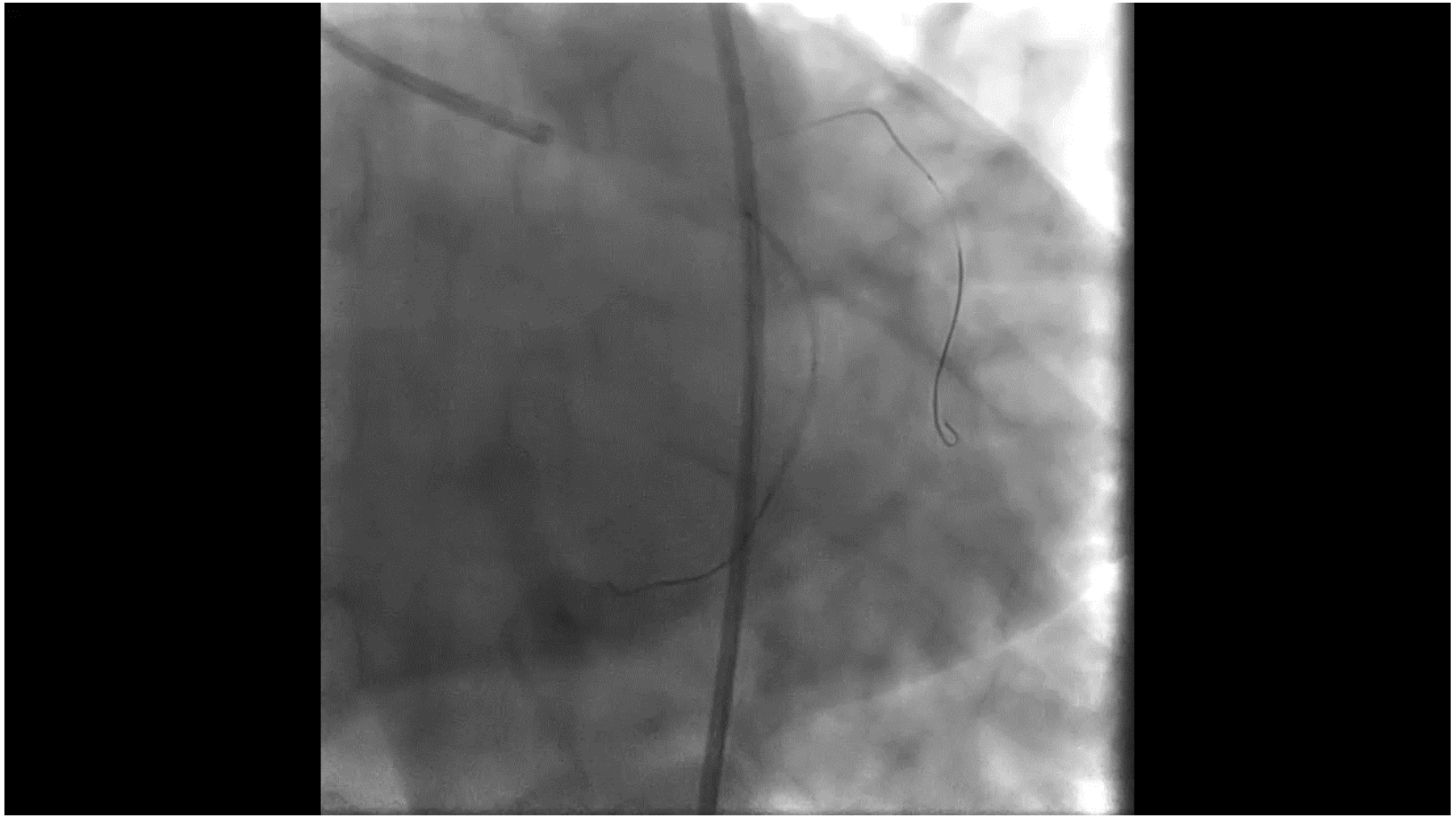
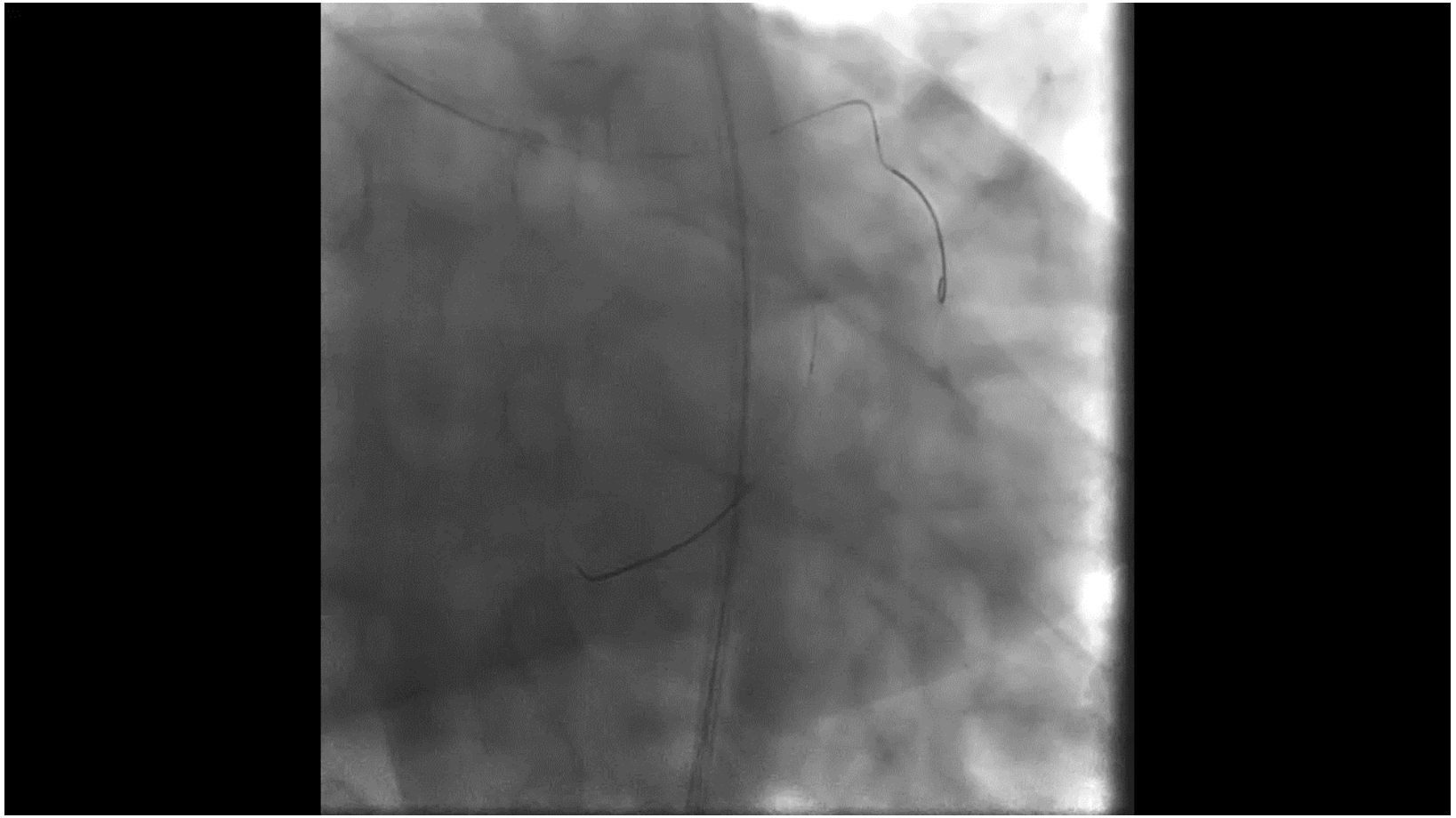
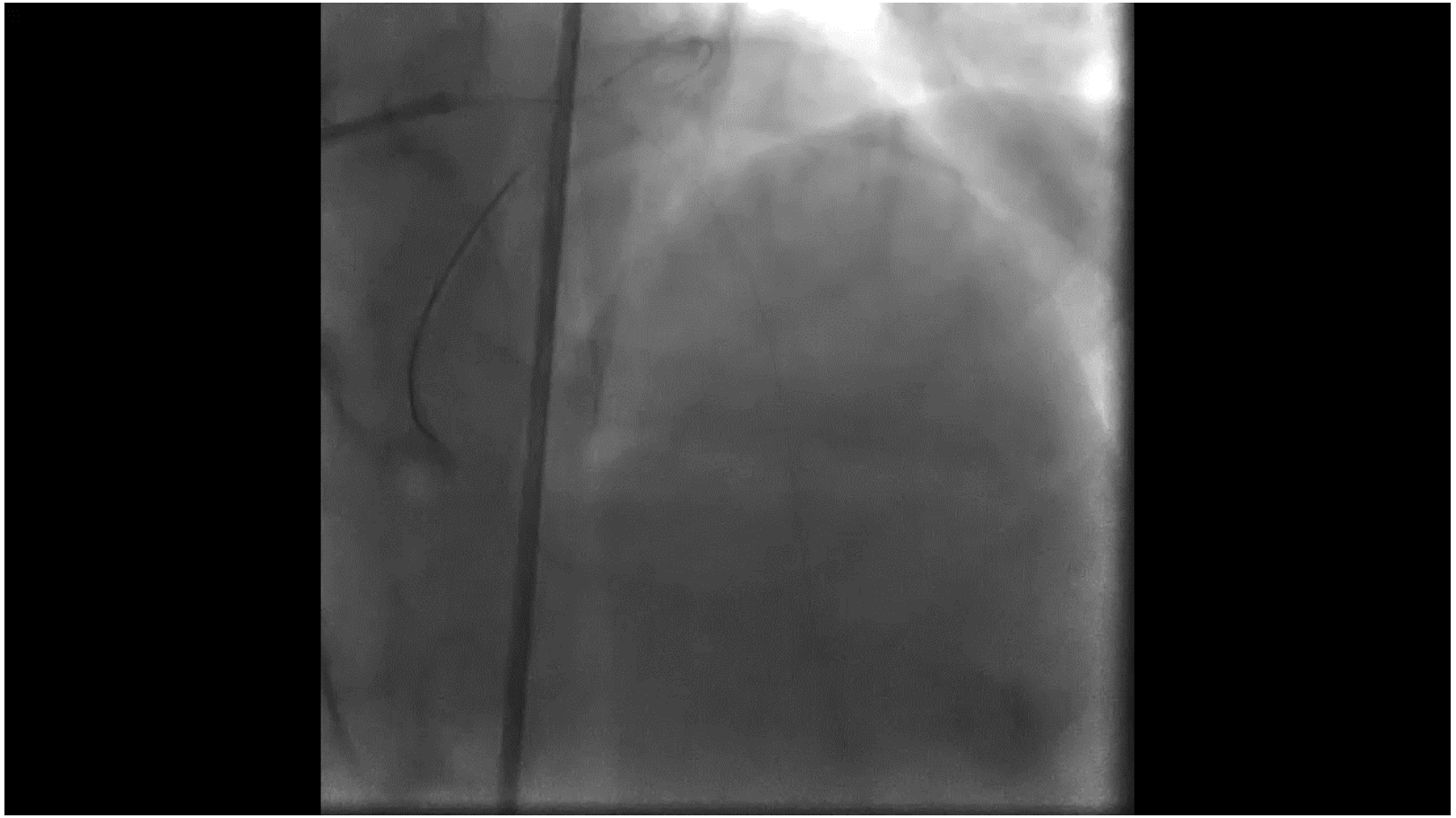


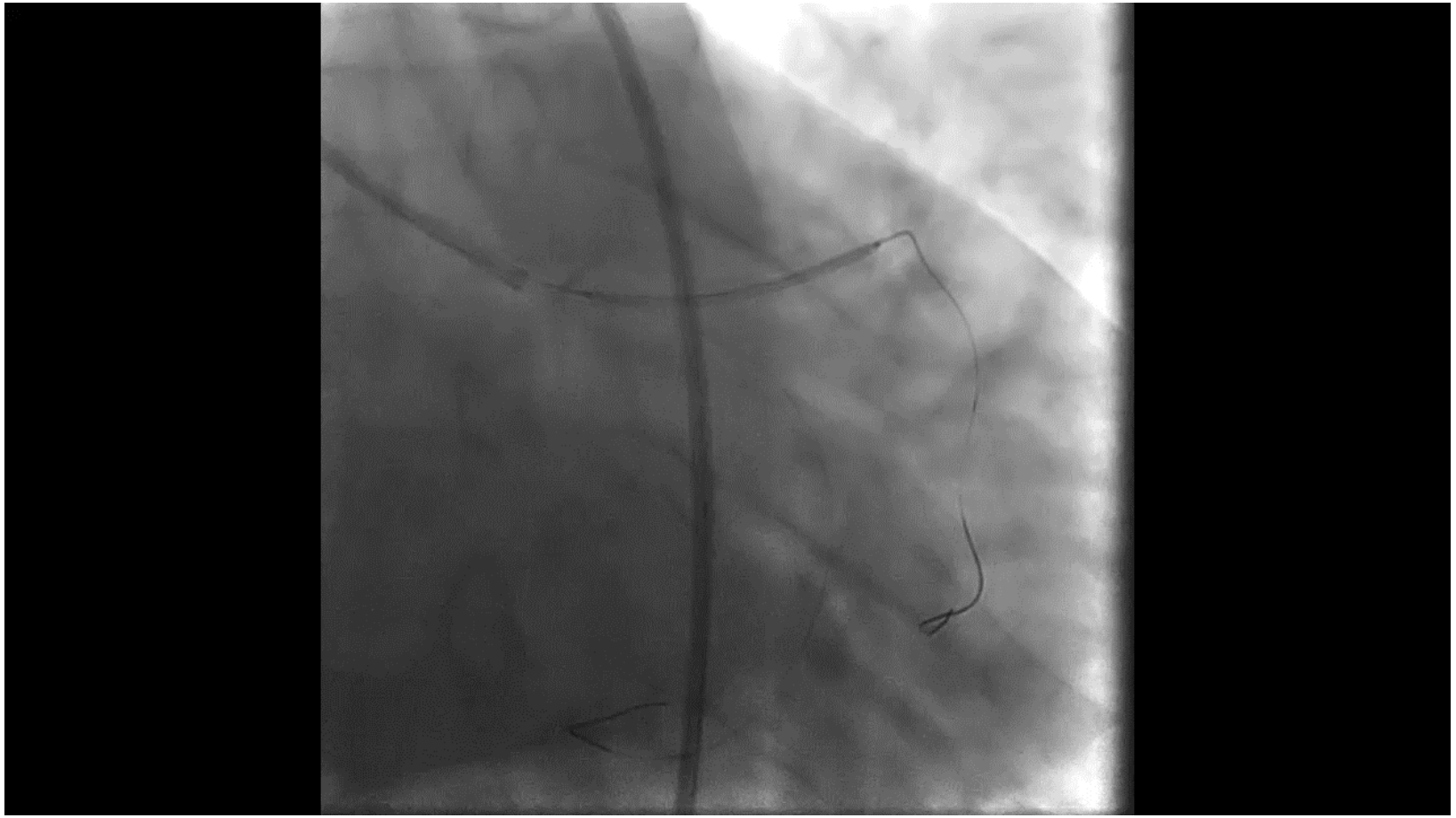
- What’s your plan?

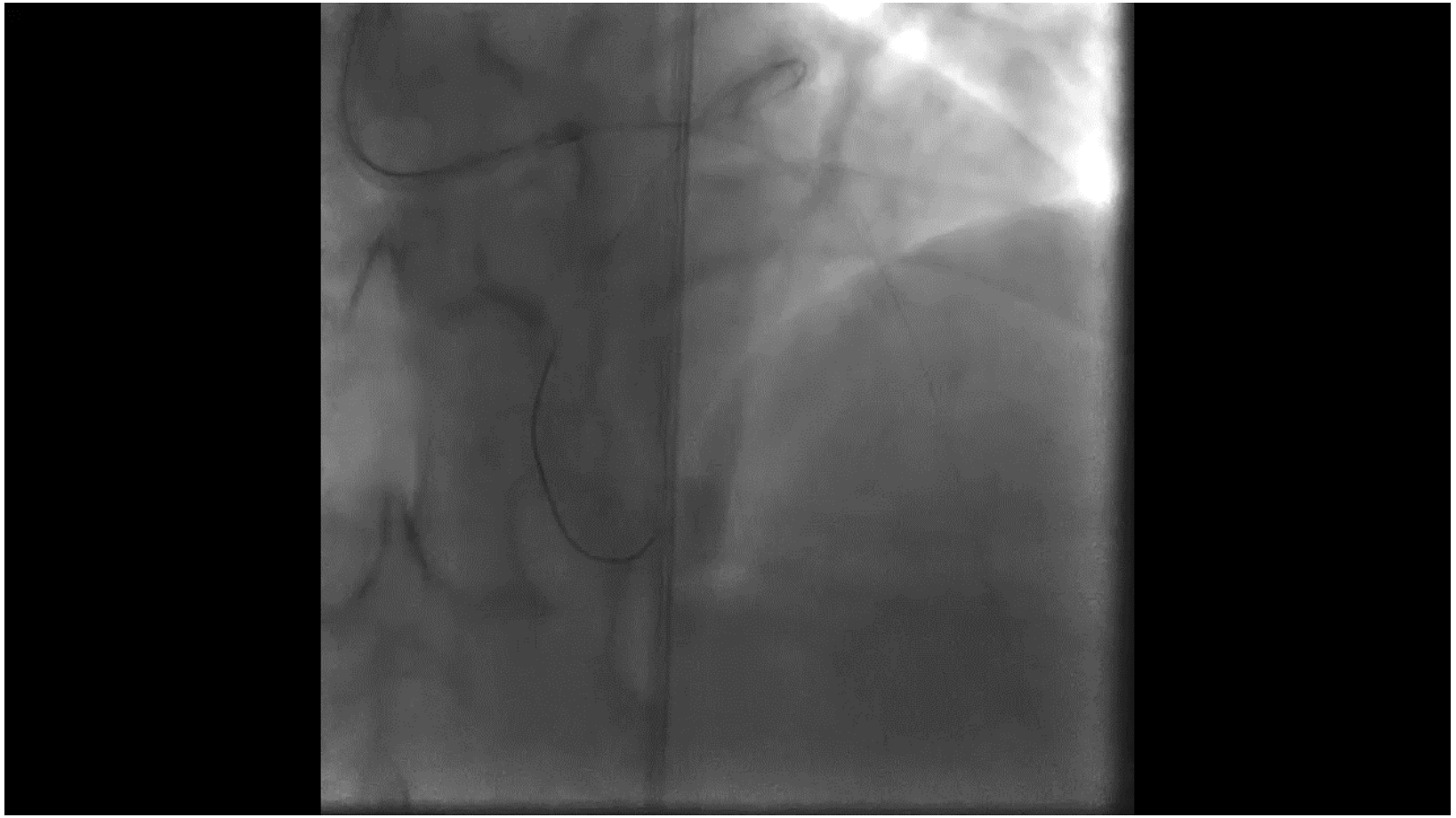


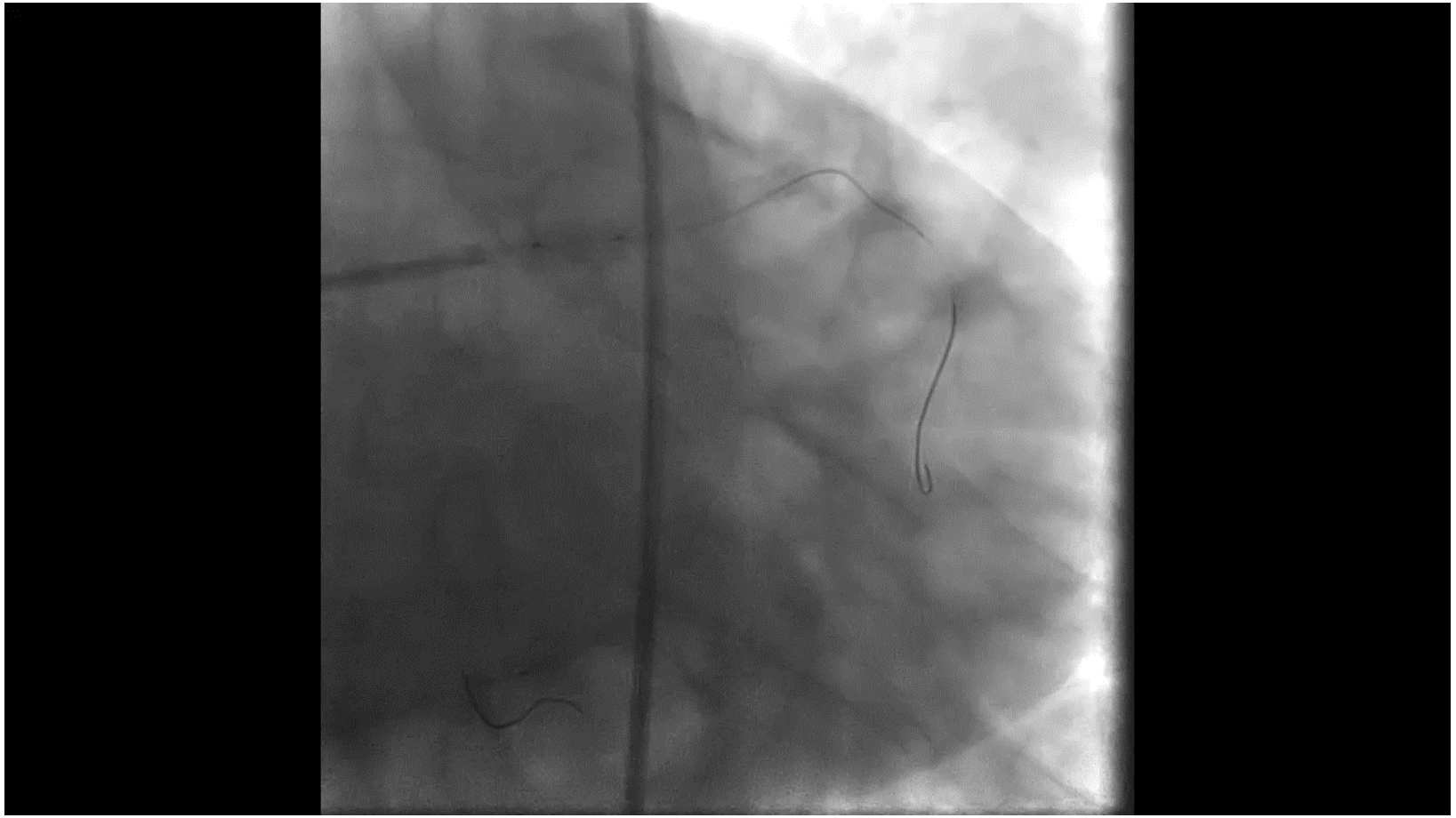


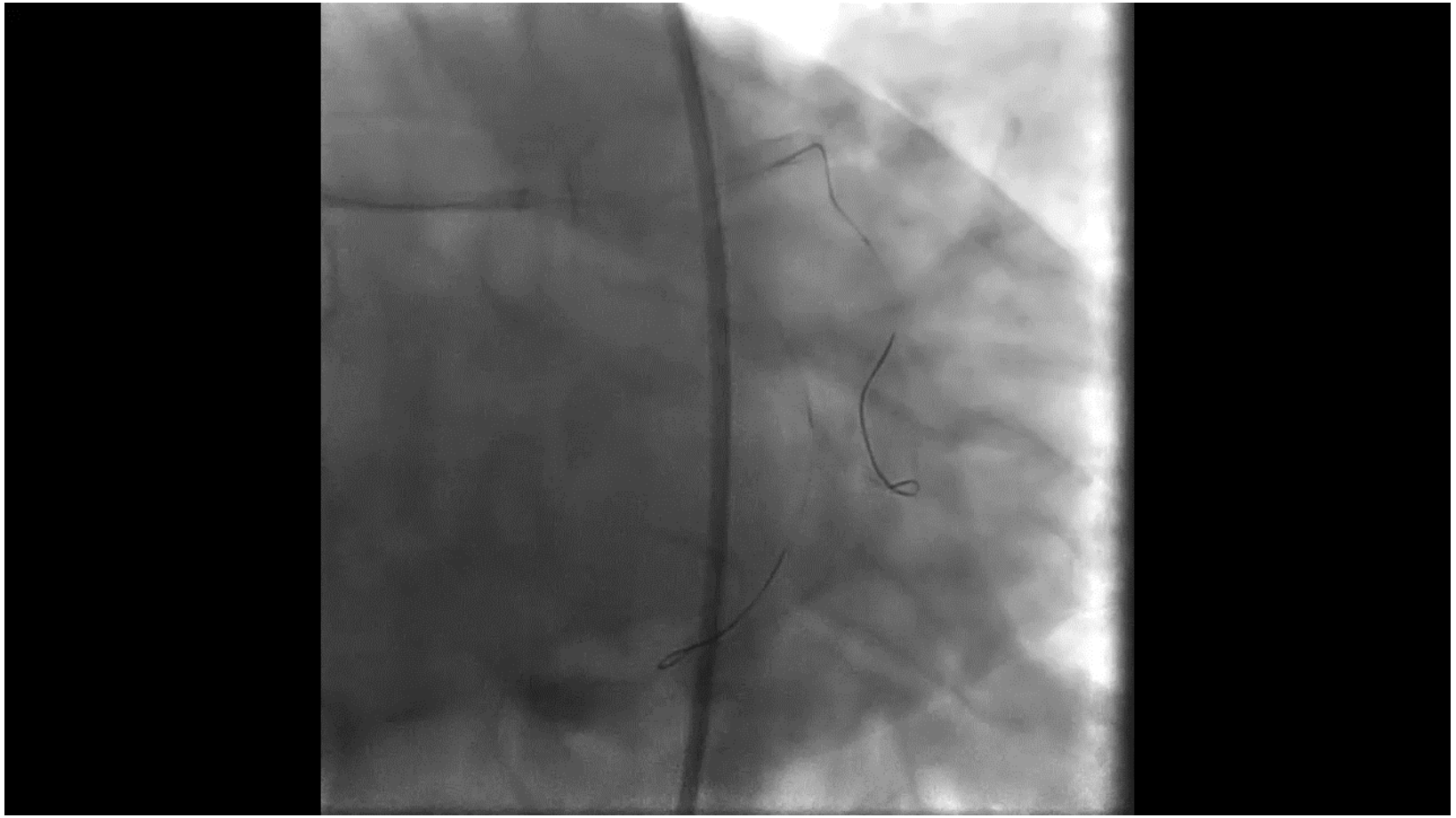


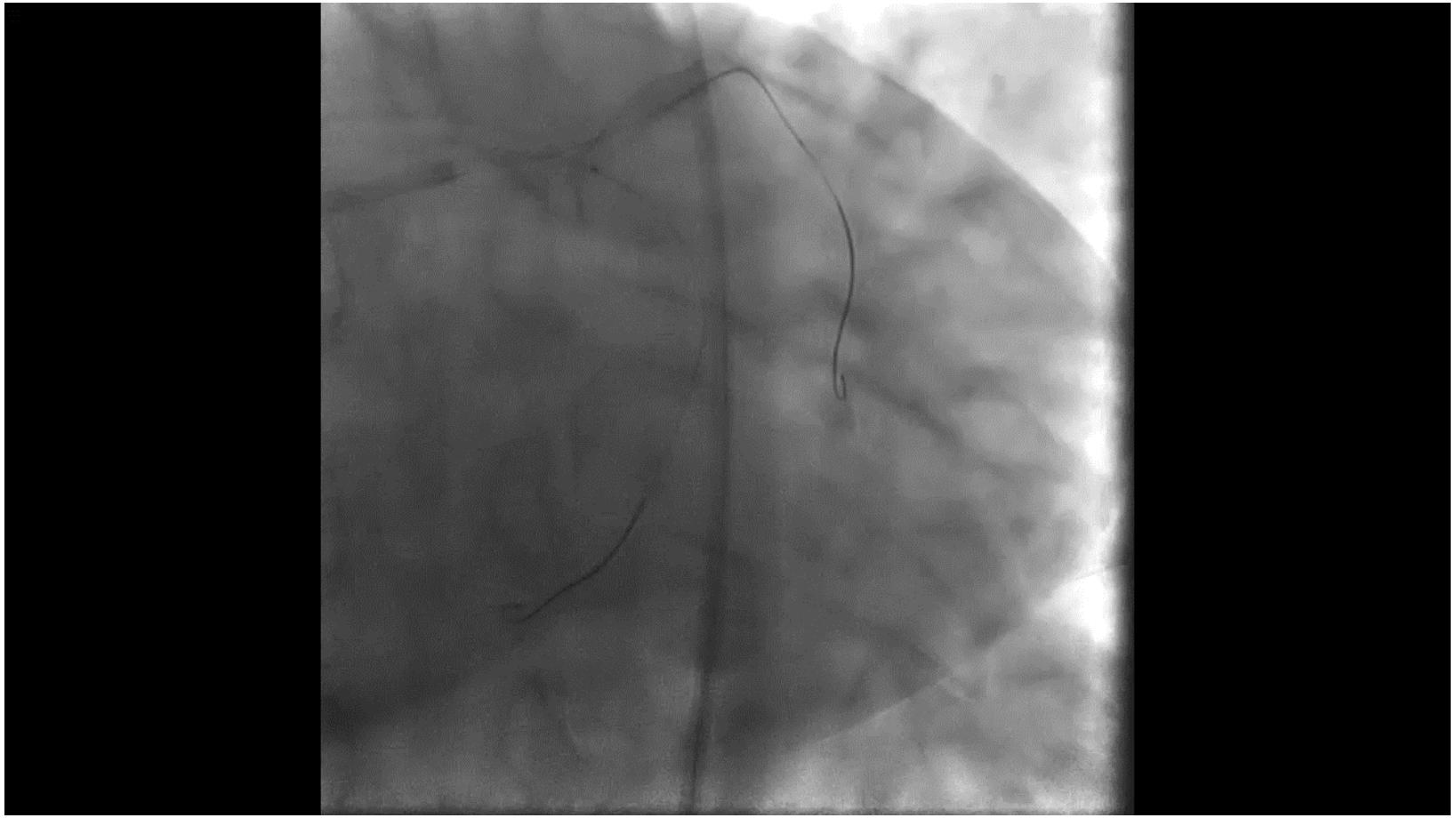


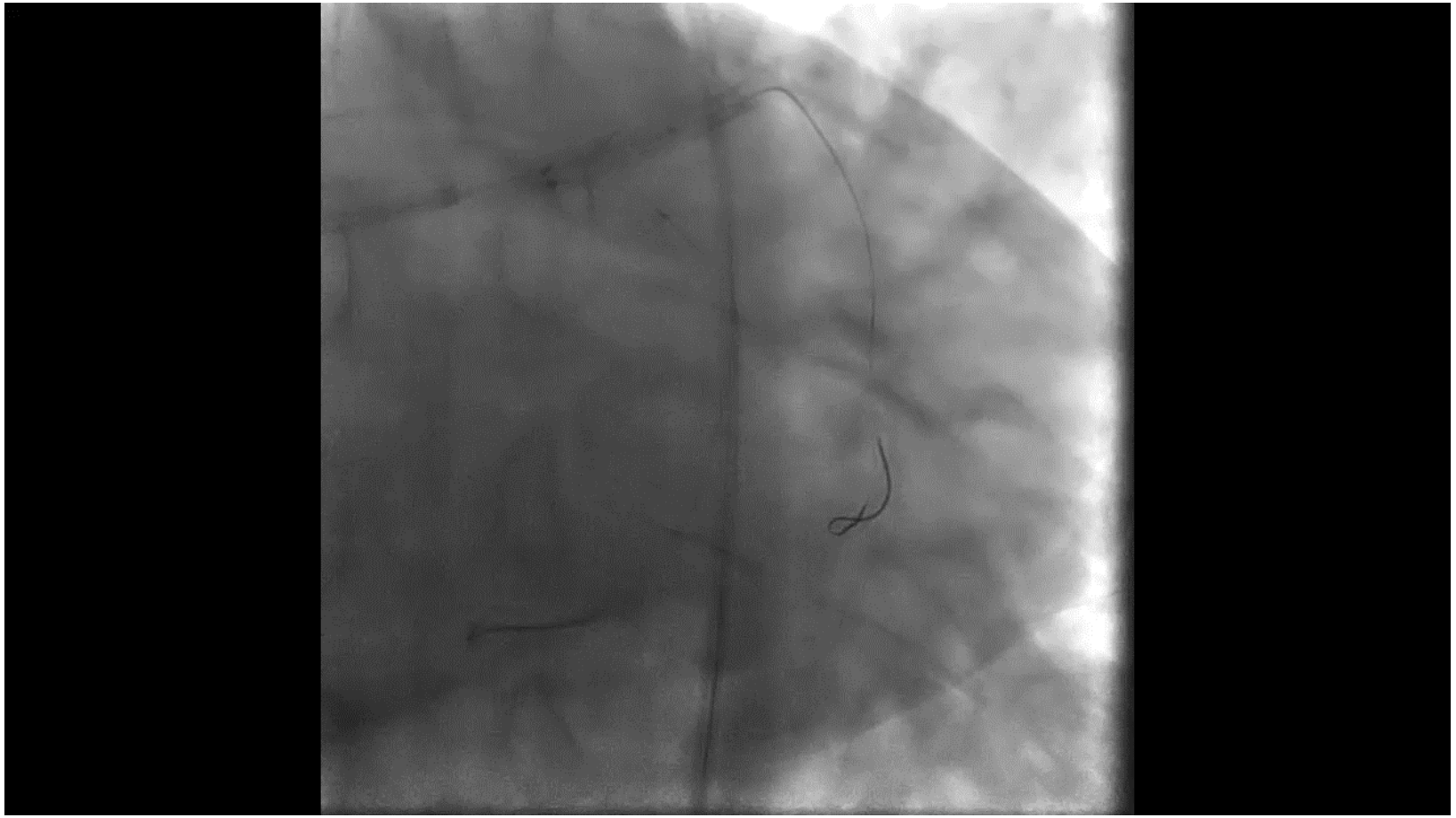


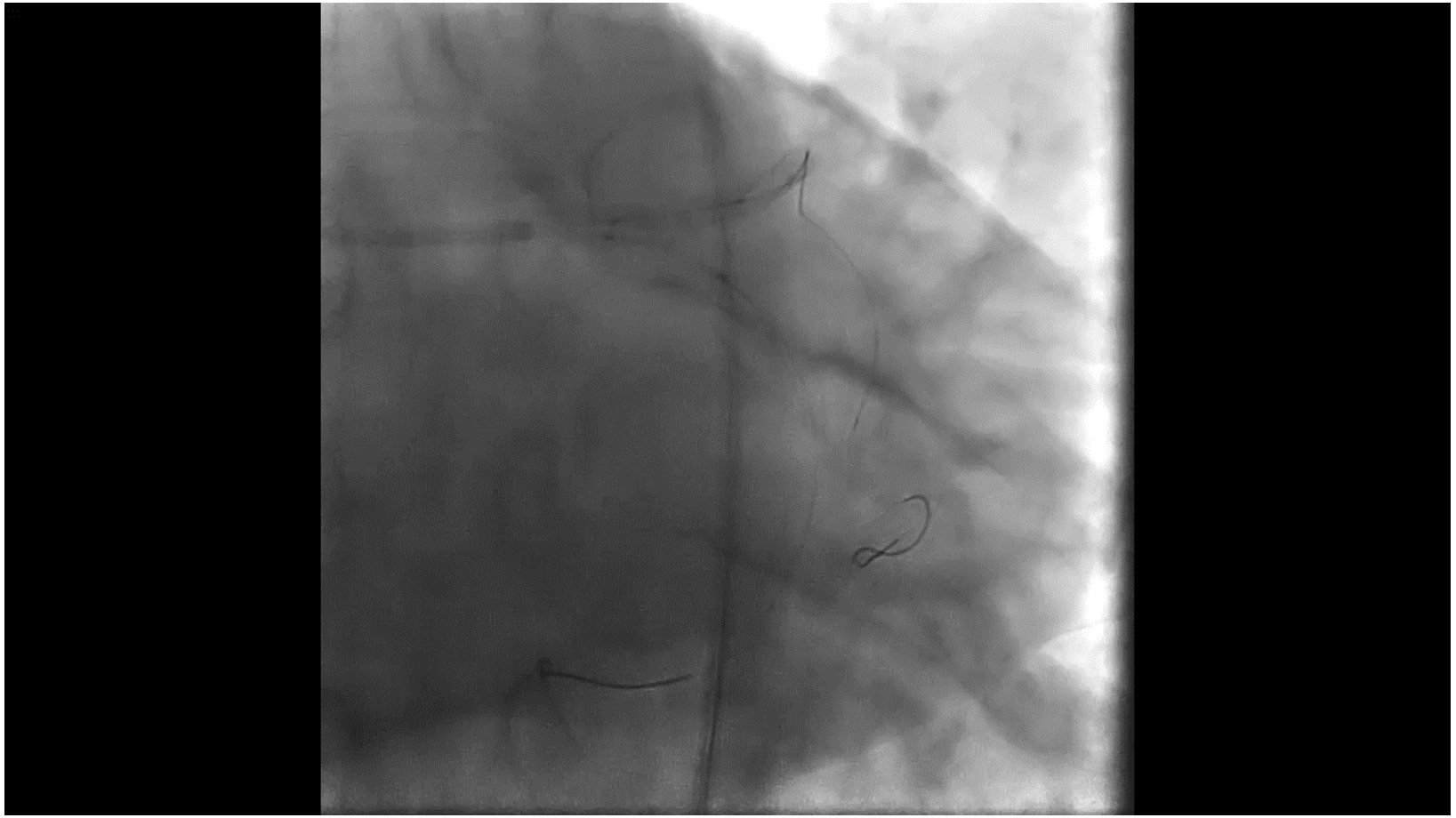


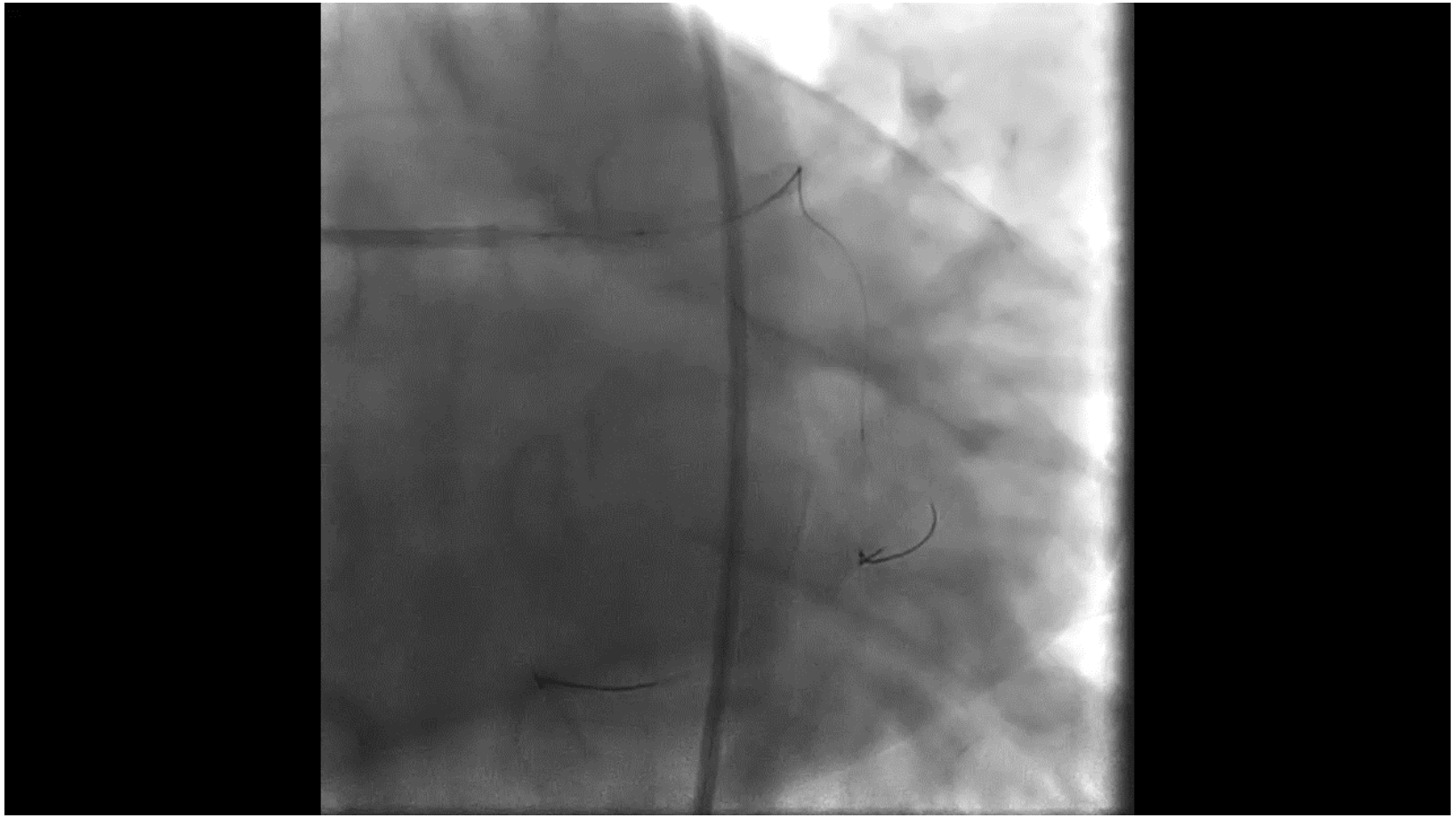


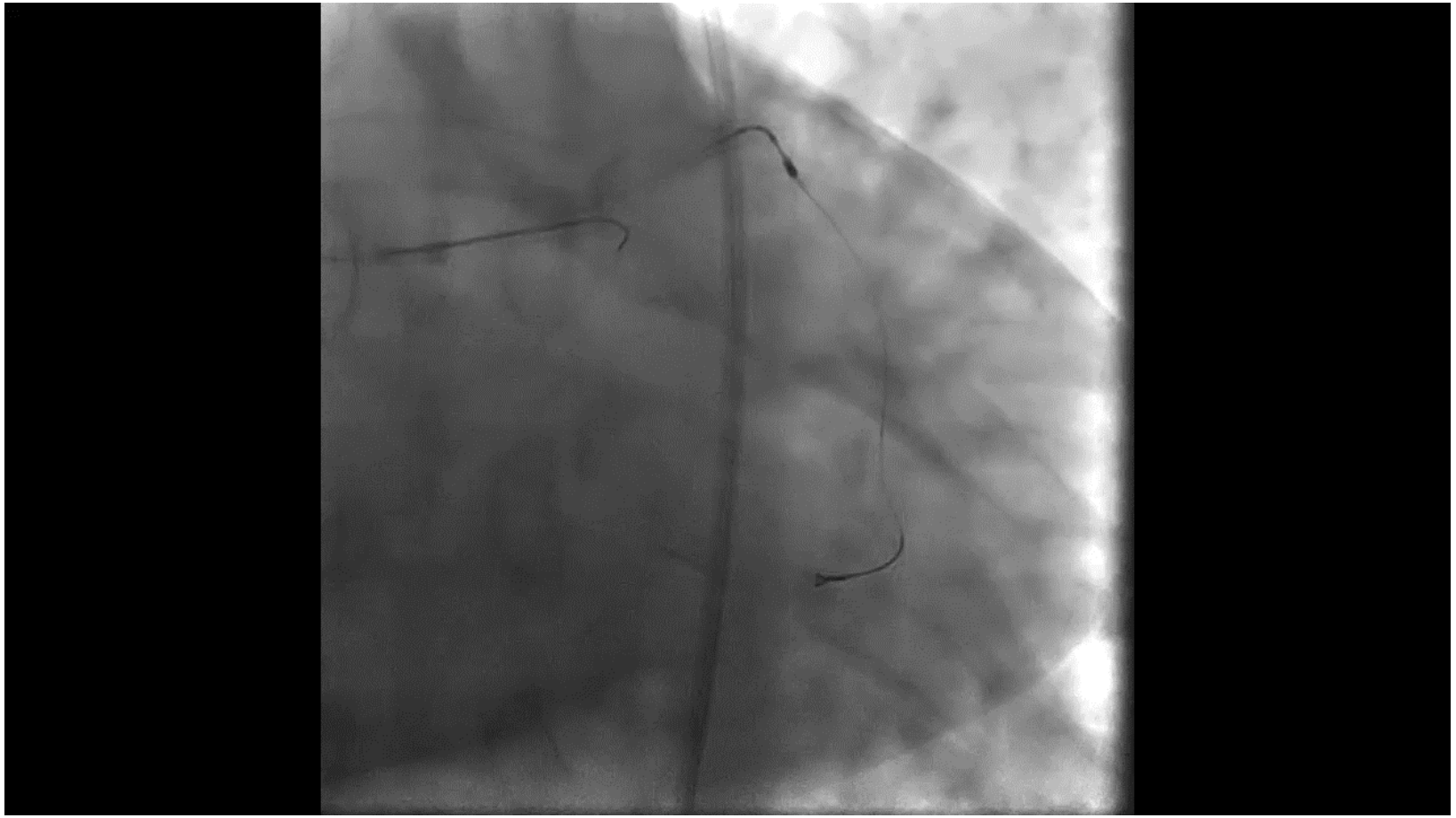


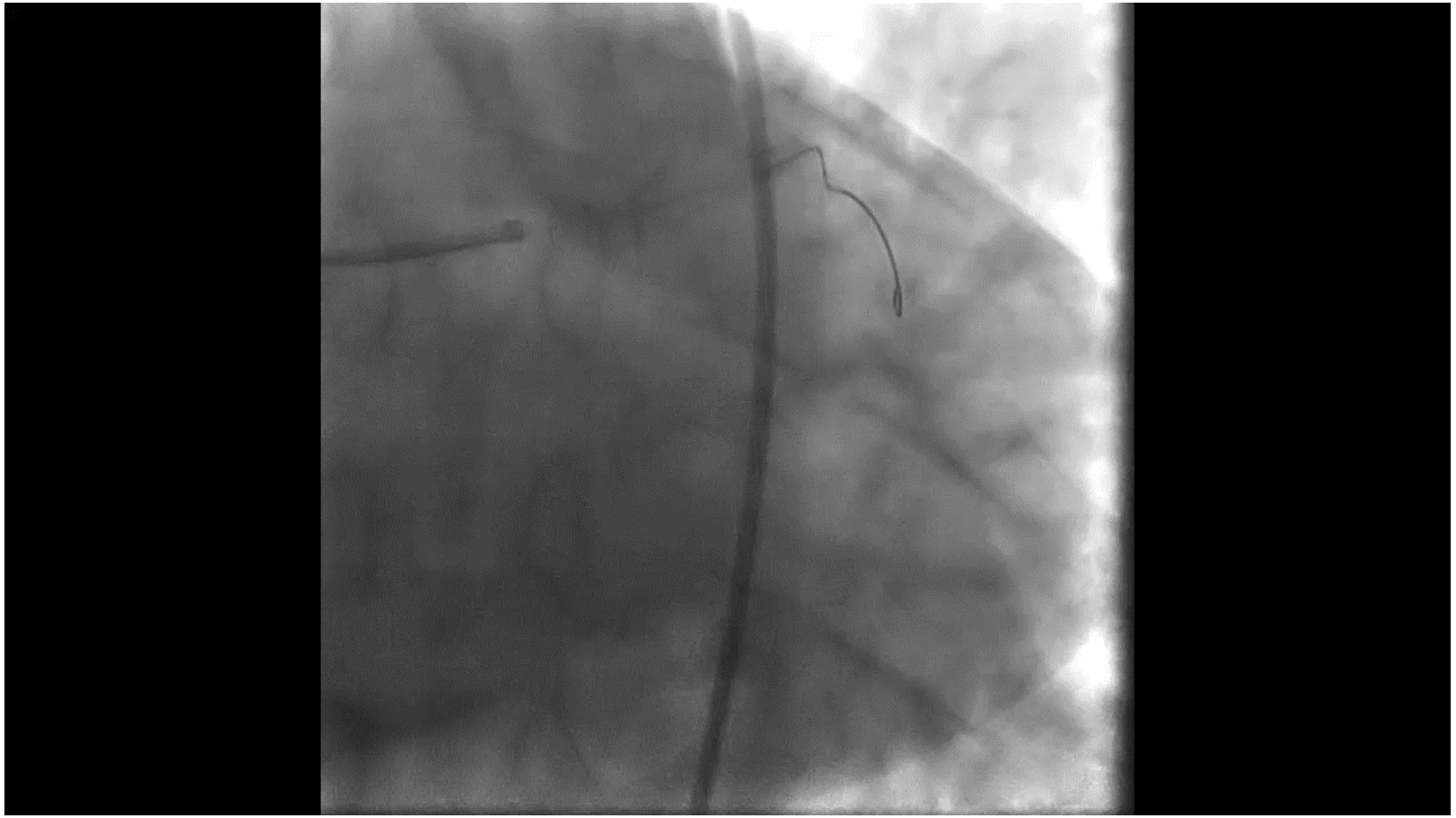


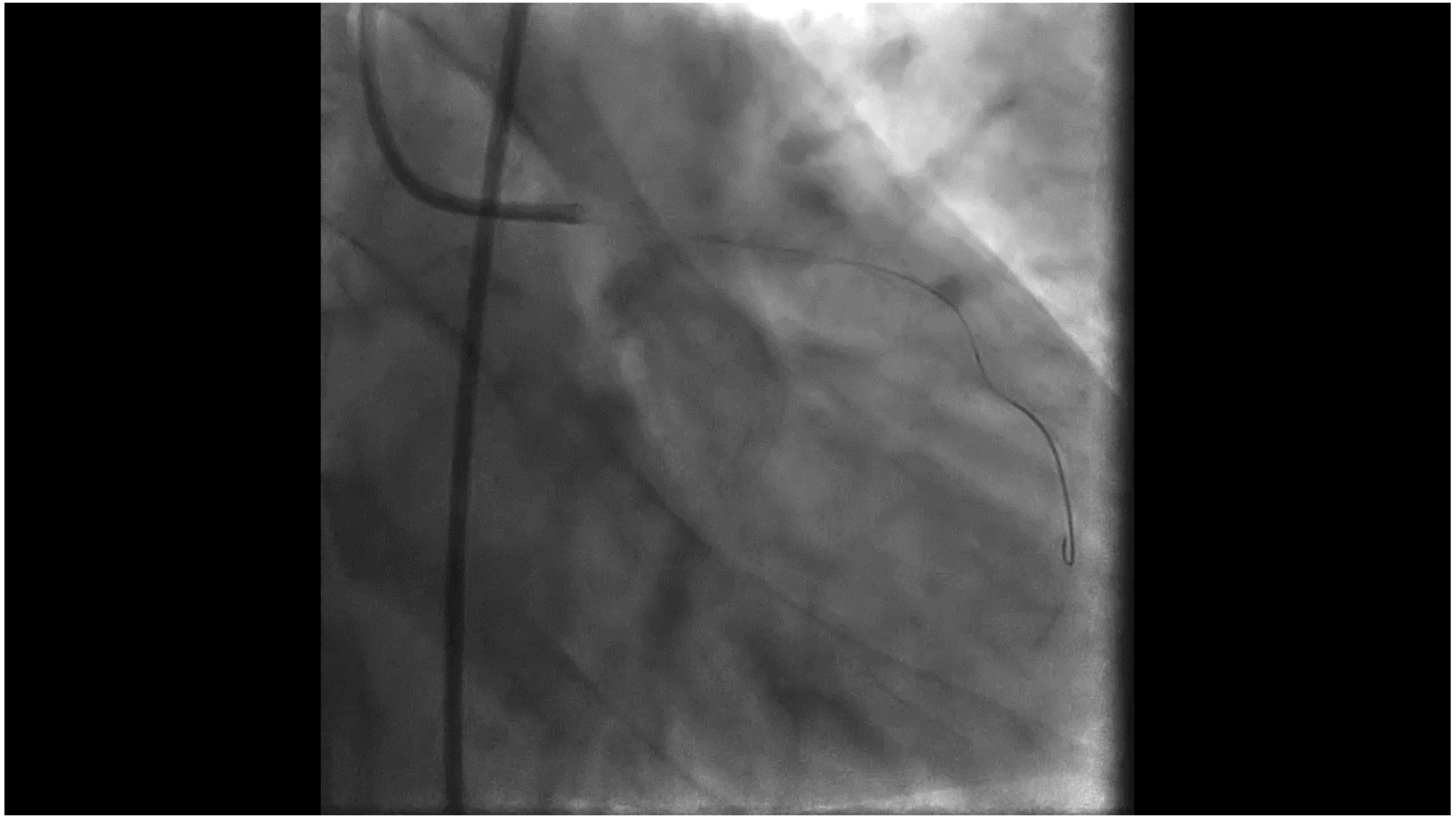












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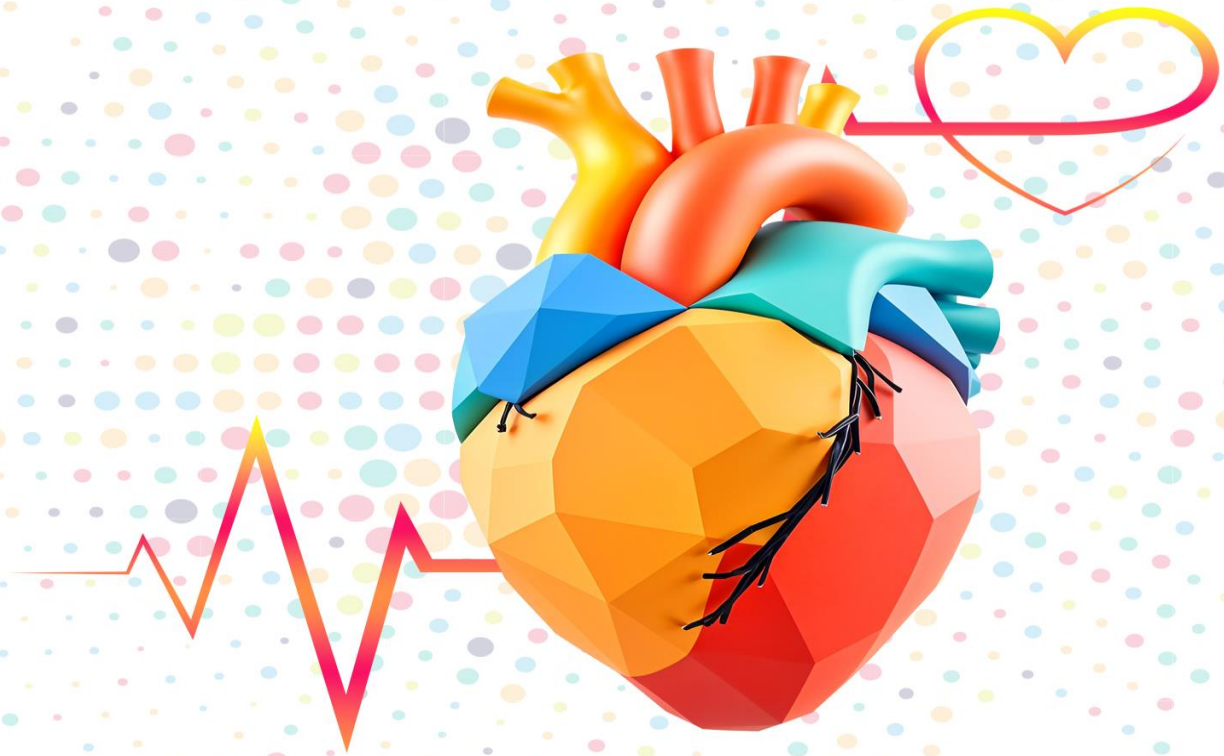
بهداشتی درمانی تهران

Critical Cardiovascular Care



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