Prevention And Treatment Of Severe LAA Closure Complications

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Disclosure

I, Teguh Santoso, have NO potential conflicts of interest

Procedural & Late Postprocedural Complications of LAA Closure: *2023 SCAI/HRS Expert Consensus Statement on Transcatheter LAAC*

Periprocedural complications	Post procedural complications
Death (< 0.2%)	**Late pericardial effusion & tamponade (~ 1%)**
Stroke (< 0.2%): ▪ **Ischemic**: air or thromboembolism ▪ **Hemorrhagic**	**Peridevice leak:** ▪ > 5 mm on TEE: 1-3% ▪ > 3 mm on TEE: 10-25%
Systemic embolism (rare)	**Device related thrombus (3-5%)**
Perforation/pericardial tamponade (~ 1%)	**Late device migration/embolization (infrequent)**
Device embolization (~ 0.2%)	**Device erosion (rare)**
Vascular complications : retroperitoneal bleed, AV fistula, pseudoaneurysm	**Iatrogenic ASD (rare to require intervention)**
Other: major bleeding, renal failure, sepsis, MI, endotracheal/esophageal damage, interfering surrounding structures, device/contrast allergy, pericarditis	

Saw J, et al. JSCAI. https://doi.org/10.1016/j.jscai.2022.100577; Available online 27 March 2023

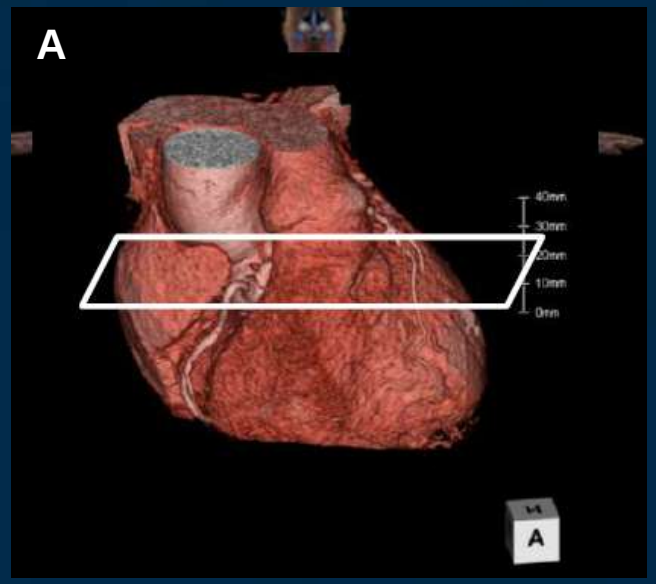
Stroke

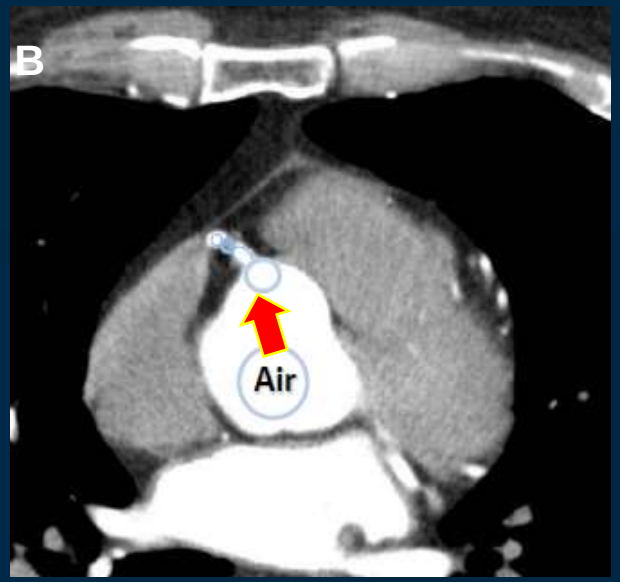
Early (peri-procedural)	Late (> 7 d post-procedure)
Air embolism	Device-related thrombus
De novo thrombus formation on equipment	Incomplete LAA closure
Embolism of pre-existing LAA thrombus	Non-LAA source of thrombus

Peri-procedural Stroke After LAAC

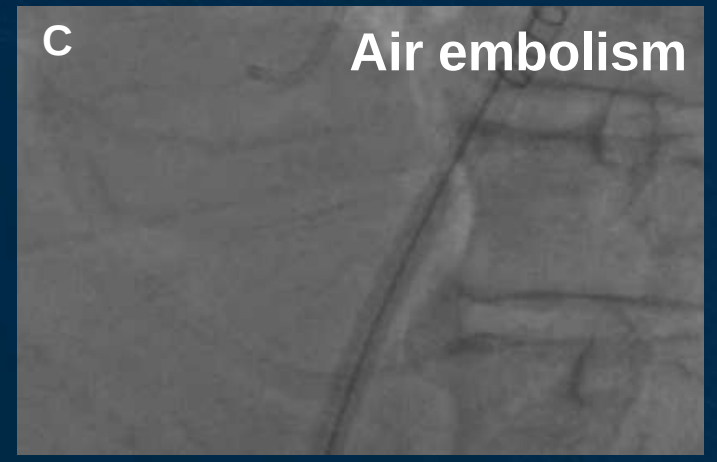
Mechanism	Prevention	Treatment
Air embolization	GA & ET intubation with ***positive intra-thoracic pressure. Maintain LA pressure > 10 mmHg***. Meticulous flushing	***The anatomy of LAA is usually oriented superiorly*** & may result in ***air entrapment*** within it. Air can be aspirated by using a pig tail catheter. ***Device implantation*** may also be considered to trap the embolized air within the LAA & the patient should remain supine for a few hours to prevent air dislodgement***. Administration of 100% O2, the Trendelenburg position, ± hyperbaric chamber***
De novo thrombus formation **on equipment**	Always have an ACT > 250 seconds. In case of difficult TSP, ***Thrombus can develop on the TSP needle or sheath***, ***Cerebral protection device*** may be considered	-----
Embolism of pre-existing LAA thrombus	***Bridging OAC therapy with heparin*** should be considered in patients at ***very high risk of stroke***	***Amulet or Lambre device*** have been used for entrapment of pre-existing thrombus in the LAA (not routinely recommended)

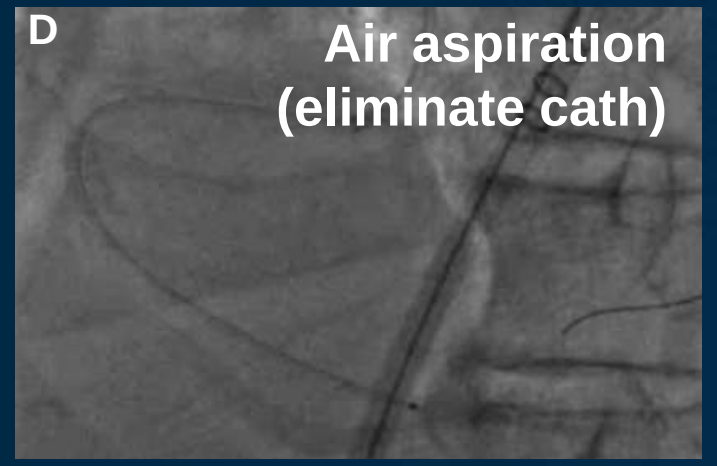
Air Embolism *To The RCA*

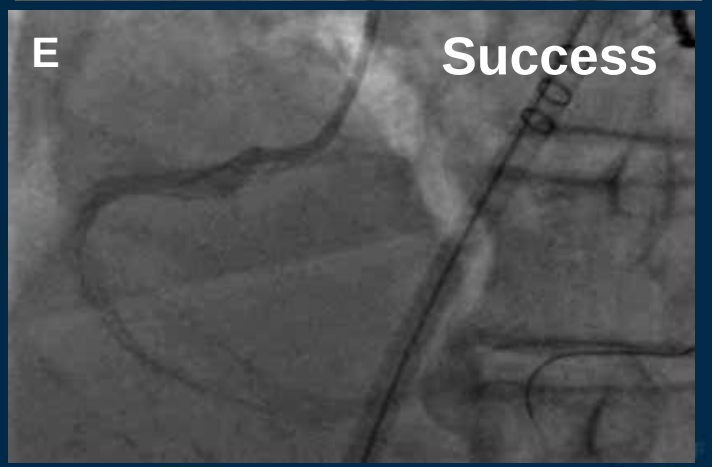




A, B. The orifice of the RCA is located at apex of Valsava by the supine position







C, D, E. This patient developed ***hypotension & sudden ST elevation in the inferior leads*** right after contrast injection to the LAA. RCA angiogram showed ***free air in the RCA without evidence of stenosis***.

Immediate air aspiration with thrombectomy catheter resulted in prompt clinical, ECG and angiographic normalization

Perforation / *Tamponade*

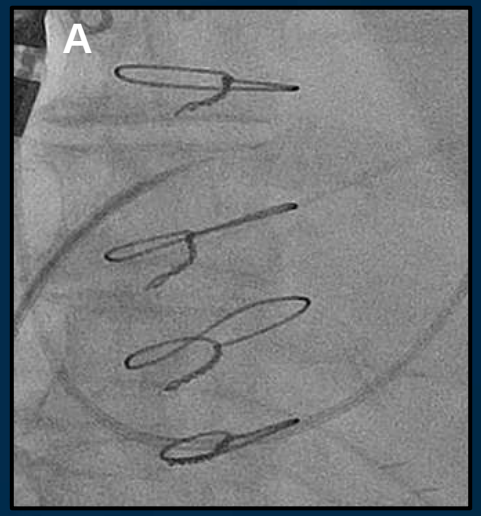
Prevention:

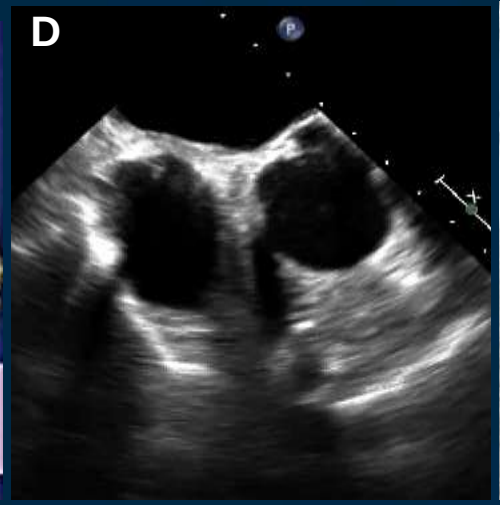
- Obtain a ***baseline assessment of pericardial space (TEE***) to exclude chronic PE
- ***Oral anticoagulant should be interrupted before LAA closure*** (LAAC). *Bridging therapy* for patient at high risk of stroke
- ***TSP: Be careful if IAS is thick, aneurysmal or leathery*** (use back-end of coronary GW, radiofrequency needle, cautery or specialized needle-free systems [SafeSept])
- Use ***pig tail catheter*** to navigate device delivery sheath to LAA. Even soft J-GW can perforate thinned-walled LAA
- ***Early detection*** important (TEE, pressure line)

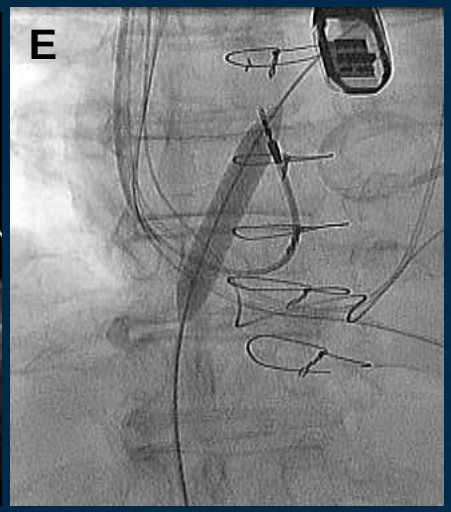
Treatment:

- ***Hemodynamic resuscitation***, ***volume expansion, drainage, autotransfusion***
- ***Anti-coagulation reversal is still controversial*** (can be associated with clotting in the pericardial space & blocking the pericardial drain)
- If the ***delivery sheath has perforated*** to the pericardial sac, ***leave in position*** until pericardial drainage is achieved & the ***surgical team*** is ready for thoracotomy.

Perforation / Transseptal Puncture:
Be Careful If IAS Is Hyperelastic, Aneurysmal Or Thick/Tough





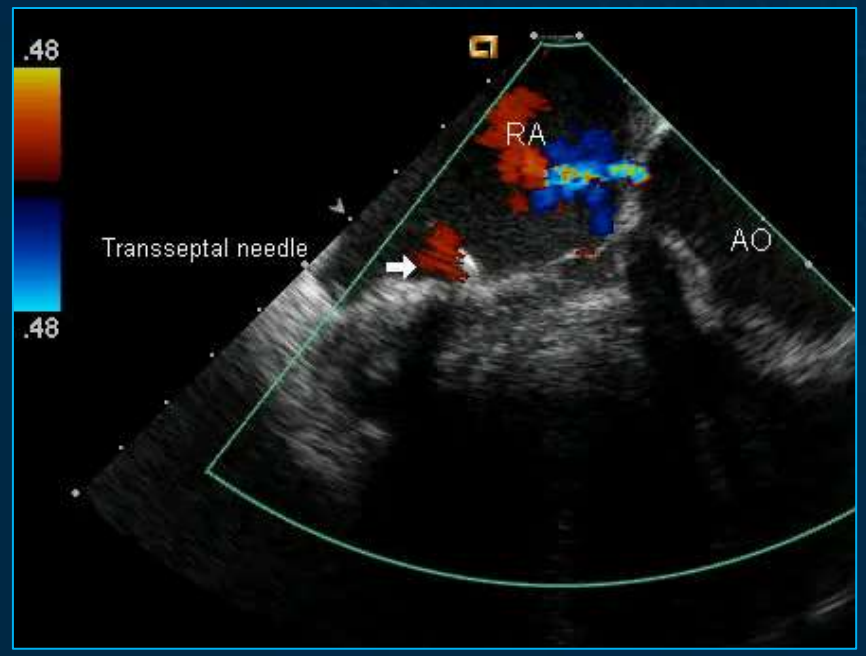


Needle Jump may perforate LA

- ***Avoid excessive tenting***.
- ***Stylet*** or ***back end of a coronary GW*** may help penetration.
- If the IAS is very thick & resistant, ***electrocoagulation*** may also help

- In rare situation where ***the needle does cross but SLO sheath/dilator cannot cross***, use a ***long exchange - length coronary GW***. The GW is threaded through the TS needle & ***looped into the LA***. Passage of SLO sheath/dilator will then be over the GW.
- ***Alternatively,*** use ***coronary balloon*** to dilate IAS before advancing the SLO sheath/dilator.

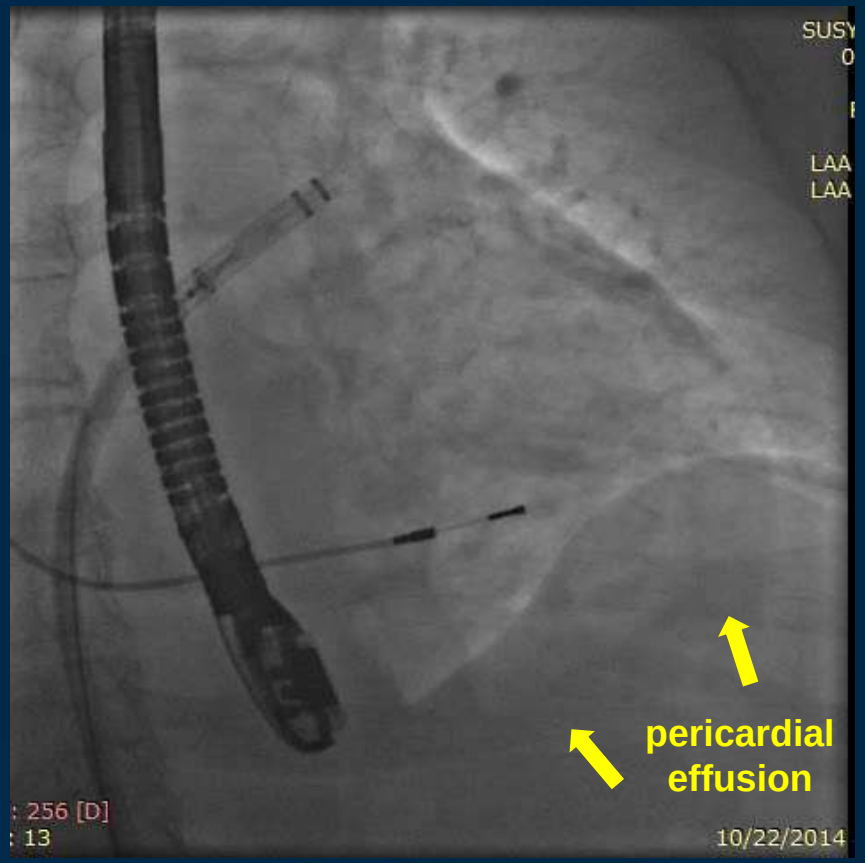
Perforation /
Inadvertent
Aortic Root Puncture

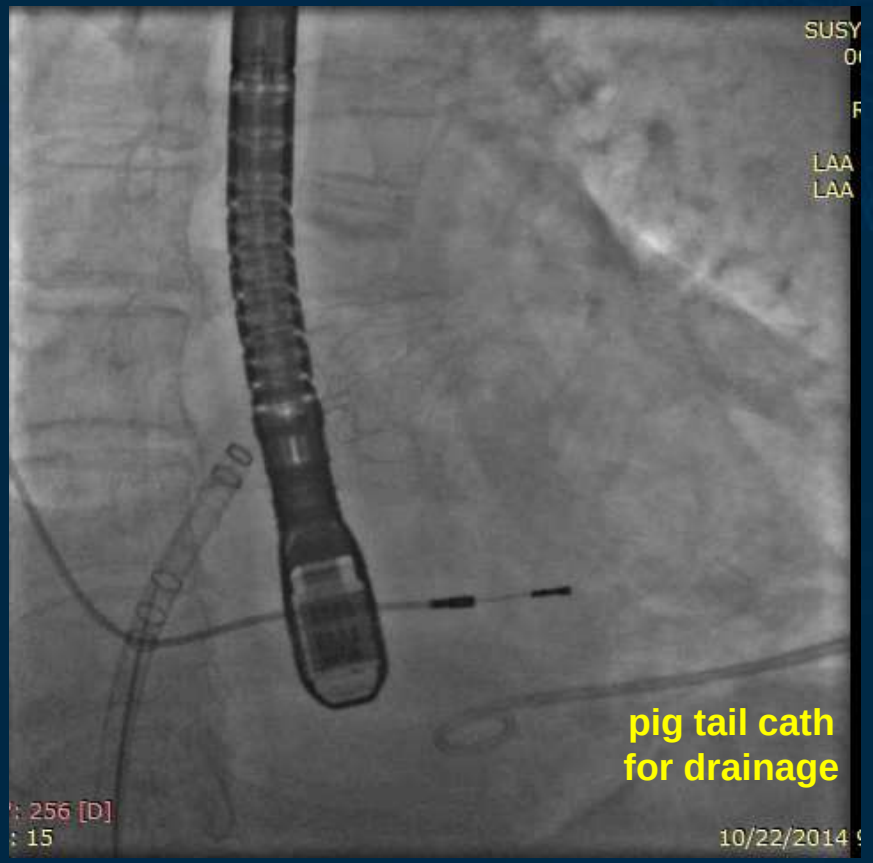


- Into the ***Non-coronary Cusp*** or ***Sino-tubular Junction*** is usually ***not associated with cardiac tamponade or a severe clinical course***
- into the ***Ascending Aorta via the epicardial space*** generally leads to ***cardiac tamponade requiring urgent pericardiocentesis surgical repair***.
  - If ***inner dilator or the complete sheath*** has penetrated the aorta, ***leave it in there***, until patient is on the operating table.
    Altenatively, ***ASO can be tried***

Chen H, et al. EP Europace, 2019; 21: 1106–1115

Perforation / *Free LA Wall Rupture*





- *Perforation induced by delivery sheath. Successfully treated with rapid implantation of Watchman device*, which completely covered the LAA ostium, sealing the perforation and …… cardio-pulmonary resuscitation, pericardial drainage (2 drains), autotransfusion, etc. …

Device Embolization

Cause	Underlying Mechanism
Device size	Implanted device is too small or generously oversized
Device position	Shallow implant (too proximal) or off-axis
Operator-related	Vigorous tug testing
Patient-related	Spontaneous reversion to sinus rhythm (restores LAA activity) Vigorous physical movement before device is sufficiently adherent
Miscelaneous	Therapeutic cardioversion soon after device implantation

Device Embolization

Prevention:

- Select ***suitable device type and size***. Device with a shorter profile for a very shallow LAA
- ***Appropriate device oversizing*** recommended (9-25% for Watchman, 2-4 mm for Amulet)
- Check the ***connection*** between device & the delivery wire during device preparation
- Assess ***device position with 2DE and 3DE and fluoroscopy with dye injection*** without overlap of the LA and LAA, and disc and lobe (or umbrella) in case of Amplatzer occluder (ACP) / LAmbre, before release
- ***Delay a few minutes*** after device deployment in the LAA before releasing the cable (to allow device to expand and accommodate to its final position
- ***Tug test*** on angiography and TEE (or ICE)
- ***Extra caution for larger device (> 25 mm)*** because they may be lodged in the LV in case of embolization (very challenging and risky to snare)
- ***Most device embolization occur early***, thus ***surveillance during the 1st 24 hours*** is highly recommended

Device embolization

Hemodynamic compromise

No

Yes

Where is the device ?

Emergent measures

- *Immediate use of a catheter/snare* to dislodge the device from occluding cardiac structures (AV, LVOT, MV, etc)
- Change patient's position (i.e. lateral decubitus)
- *Immediate surgery* if the above measures fail

Device in the LA

- ***Transseptal access snaring***
- Large bore sheath
- Device may damage/obstruct the MV
- Migration to the LV should be avoided

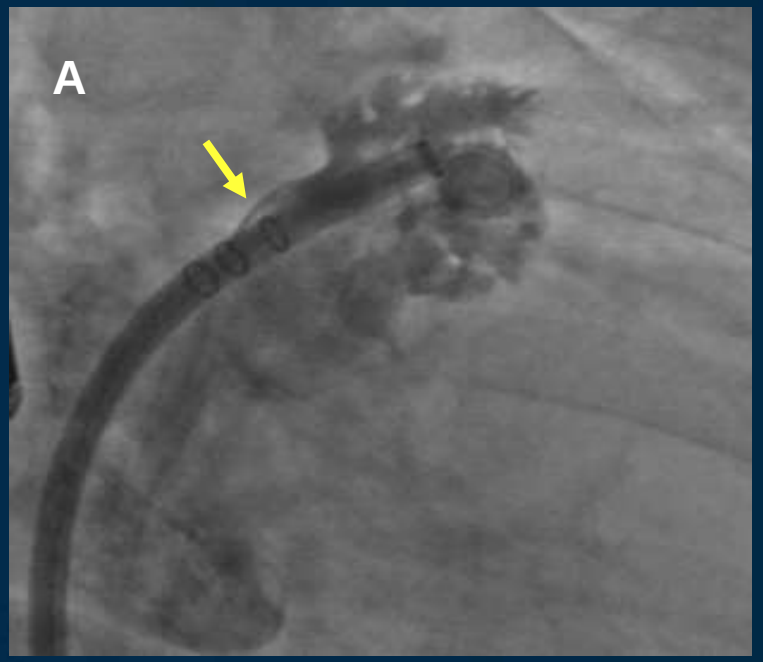
Device in the LV

- Snaring may damage the MV or AV – careful maneuvers are needed
- Pig tail catheter through the AV can help dislodge entrapped devices in the chordae
- Retrograde snaring through the AV may be performed cautiously
- ***Surgery usually needed***

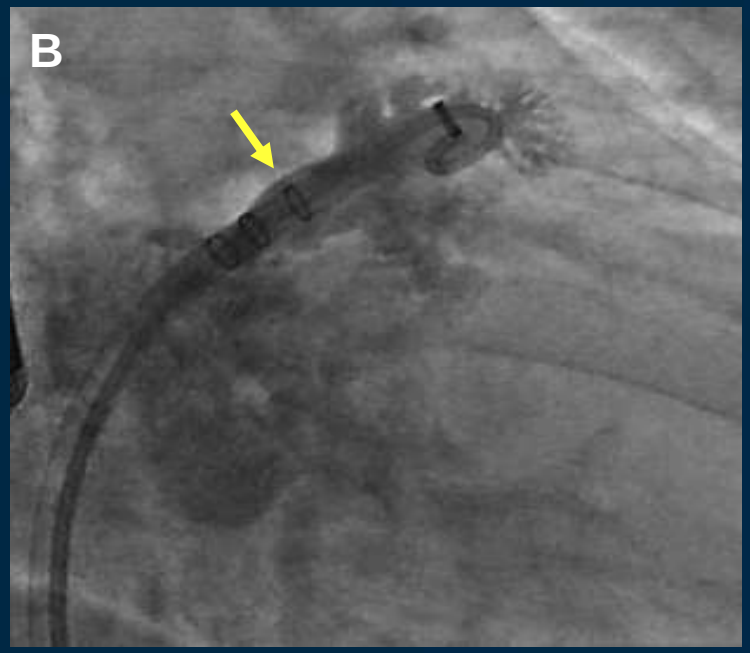
Device in the aorta

- ***Snaring*** in the descending aorta is preferable

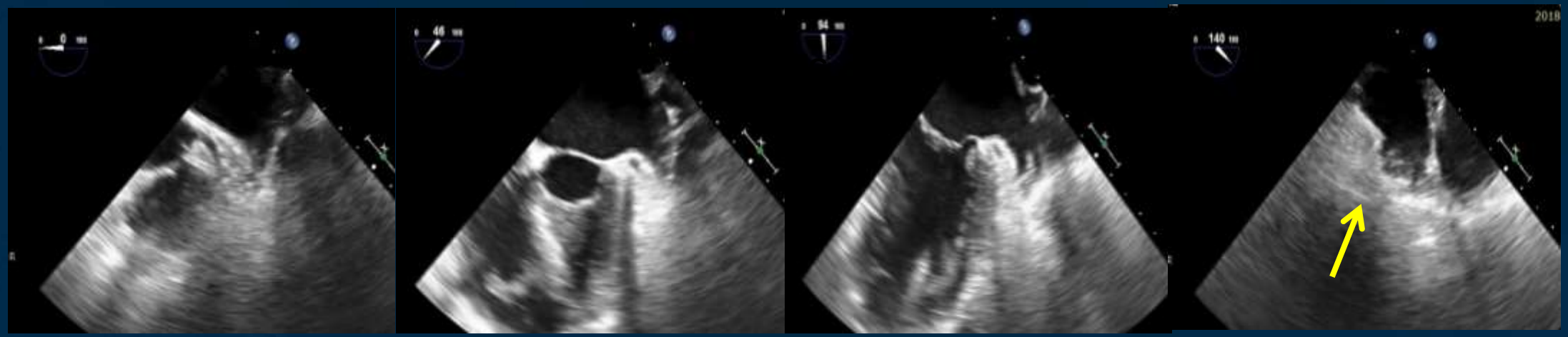
Device Embolization



A. Small LAA with prominent pectinate muscles.
Note: position of distal marker of the delivery catheter (DC)

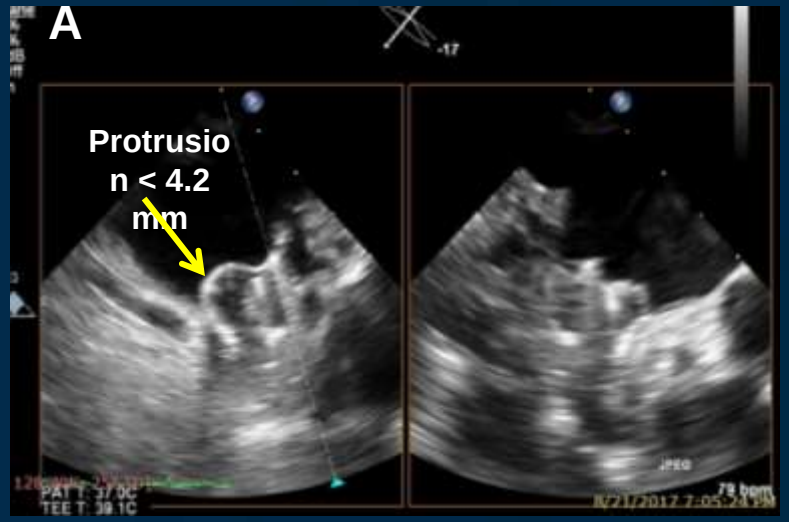


B. LAA gram (RAO 35^0/caudal 11^0) of the anterior lobe showing prominent pectinate muscles.
Note: distal marker of DC

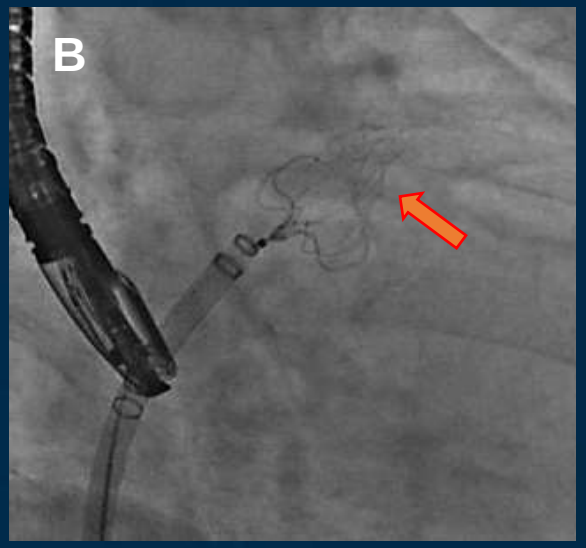


A-D. Small, shallow LAA with prominent pectinate muscles (arrow)

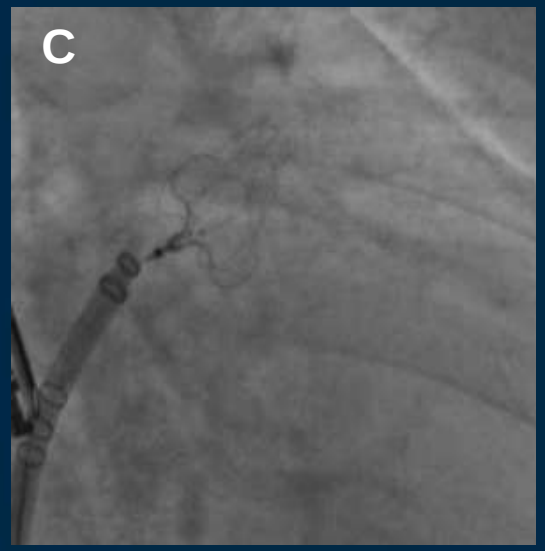
Device Embolization



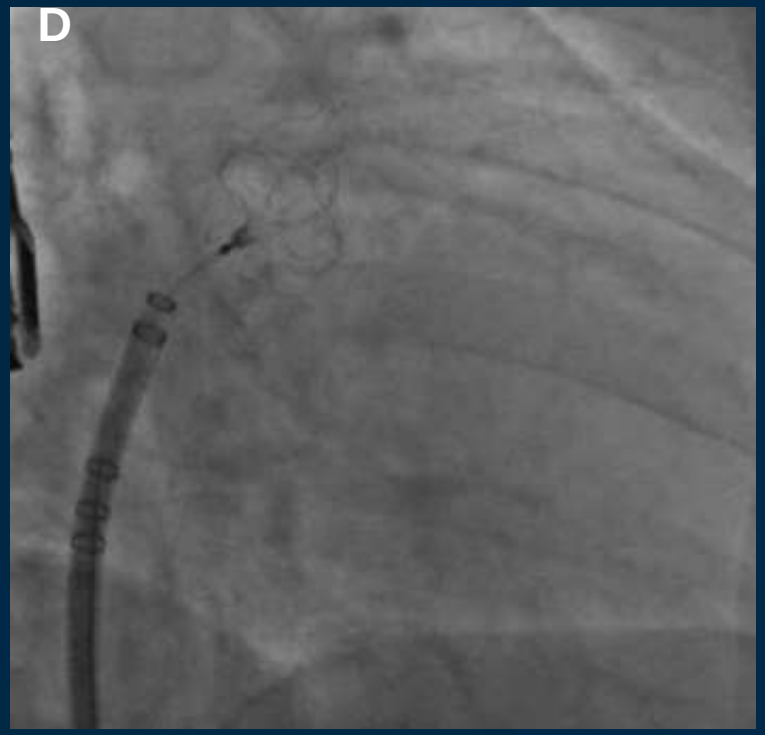
A. Watchman device (24 mm) deployed, all LAA lobes covered, compression was good (26%), no leakage, tug test was good, mild protrusion to LA



B. ***Watchman device appeared deformed by pectinate muscles*** (arrow)



C. ***Tug test was satisfactory, but too vigorous.*** LAA moved in unison with the device.



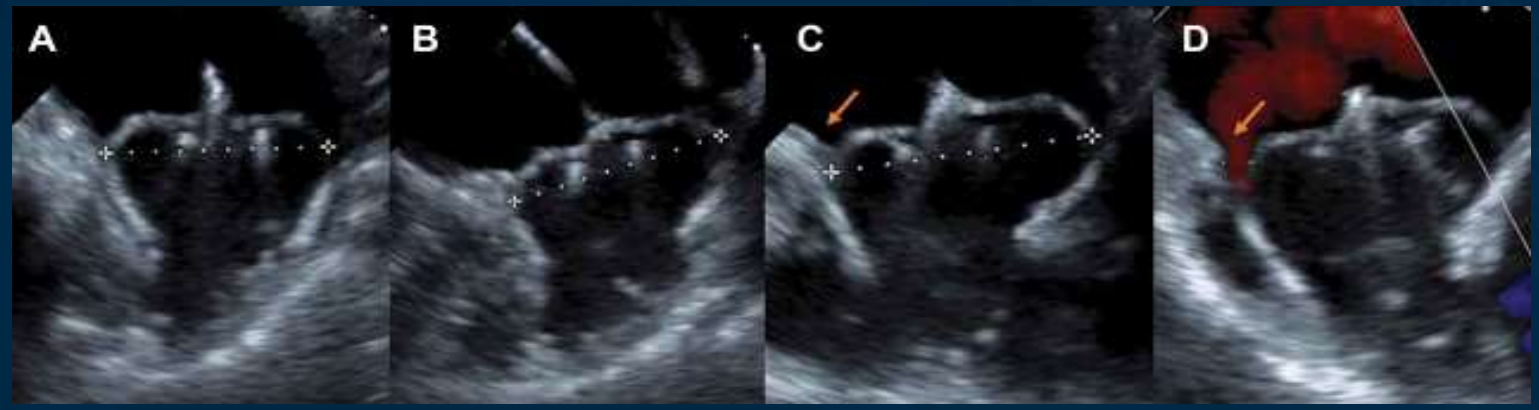
D. ***Device embolization,*** immediately release

D. ***Watchman device was snared*** & pulled out

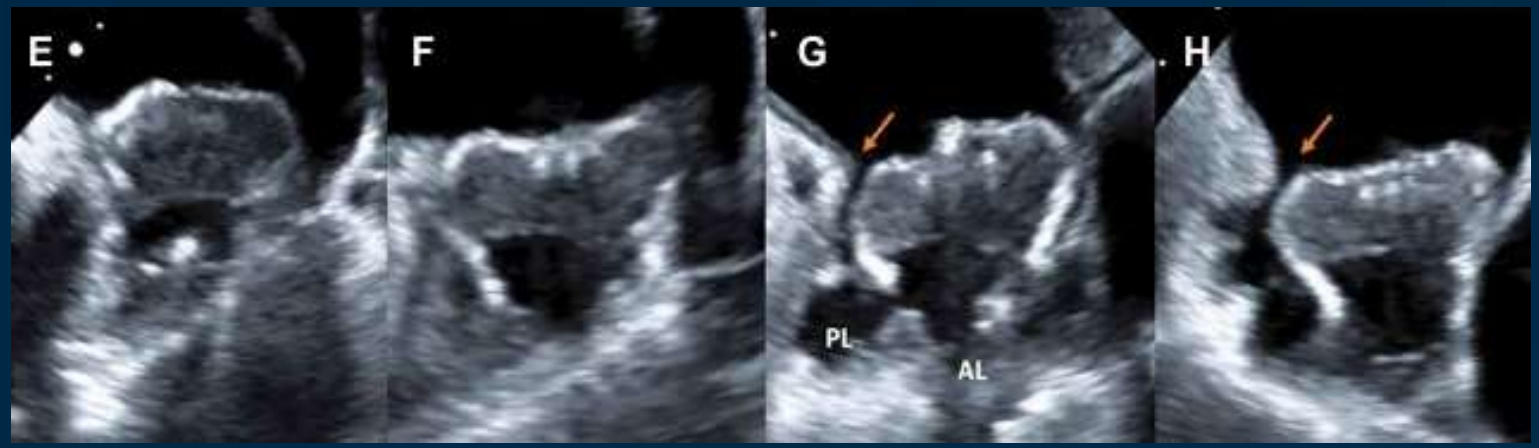
Peridevice Leak (PDL):

Associated With An Increased Risk Of Thromboembolic Events

After Watchman deployment: **Adequate compression & <5-mm leak**



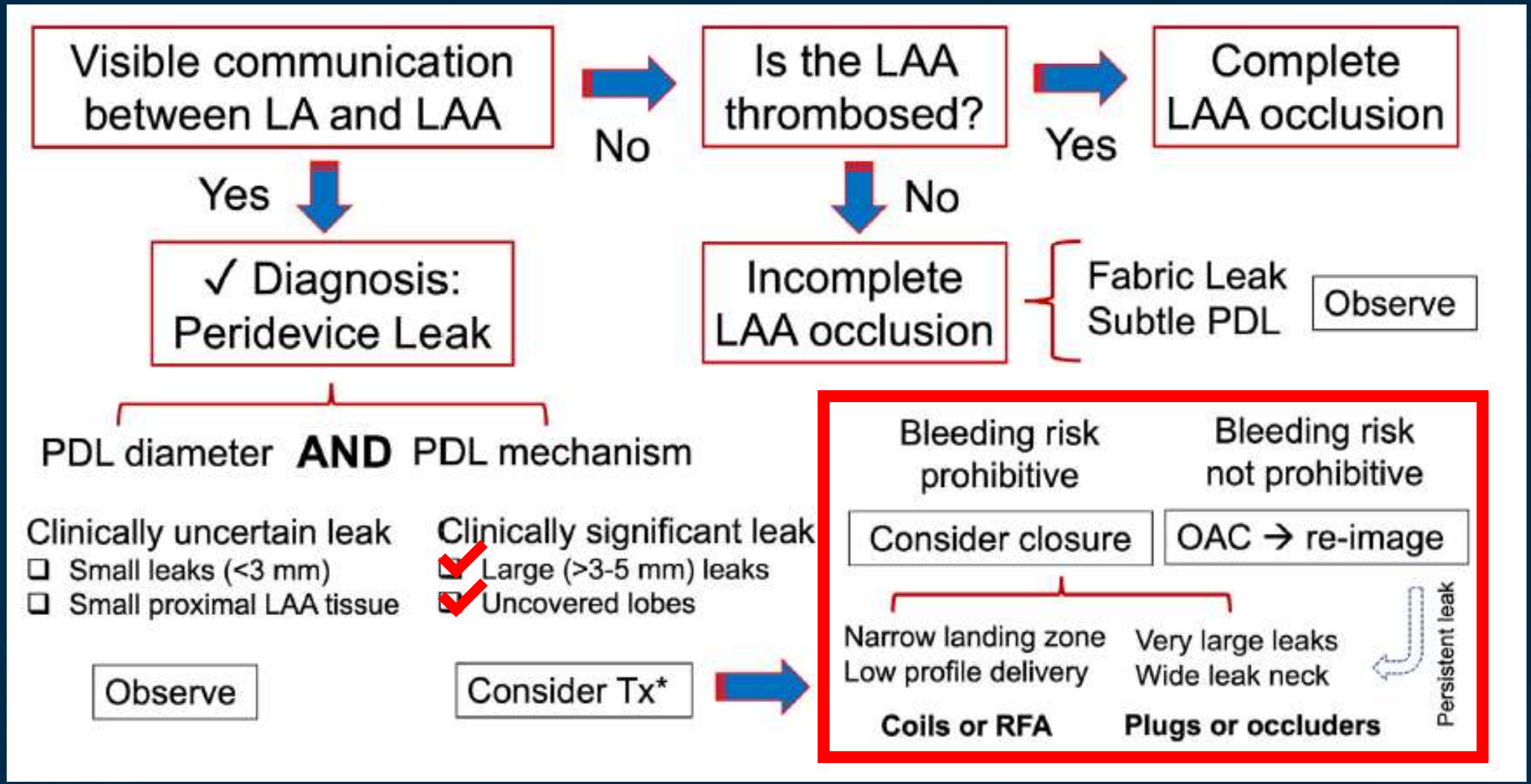
At 45-day f. up: **Large leak with an open posterior lobe**



No consensus on the management. ***OAC is generally recommended if PDL is > 5 mm.***
The feasibility of closing leaks using ***occlusion or plug devices or coiling or RF ablation is unknown***

1. Alkhouli M, et al. J Am Coll Cardiol Intv 2023;16:627–642; ; 2. Saw J, et al. JSCAI. https://doi.org/10.1016/j.jscai.2022.100577; Available online 27 March 2023

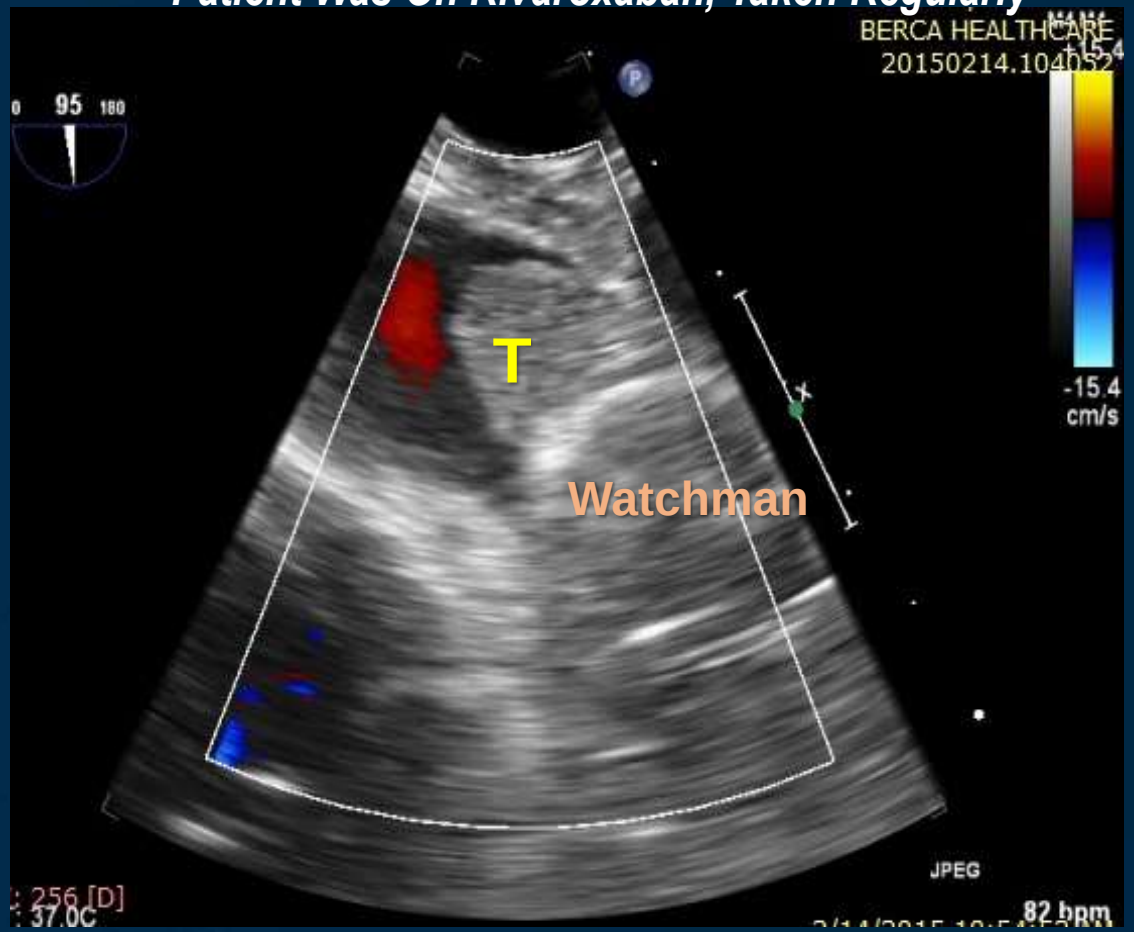
Proposed Algorithm for the Diagnosis & Management of PDLs



Alkhouli M, et al. J Am Coll Cardiol Intv 2023;16:627–642

Device –Related Thrombus (DRT)

Patient Was On Rivaroxaban, Taken Regularly



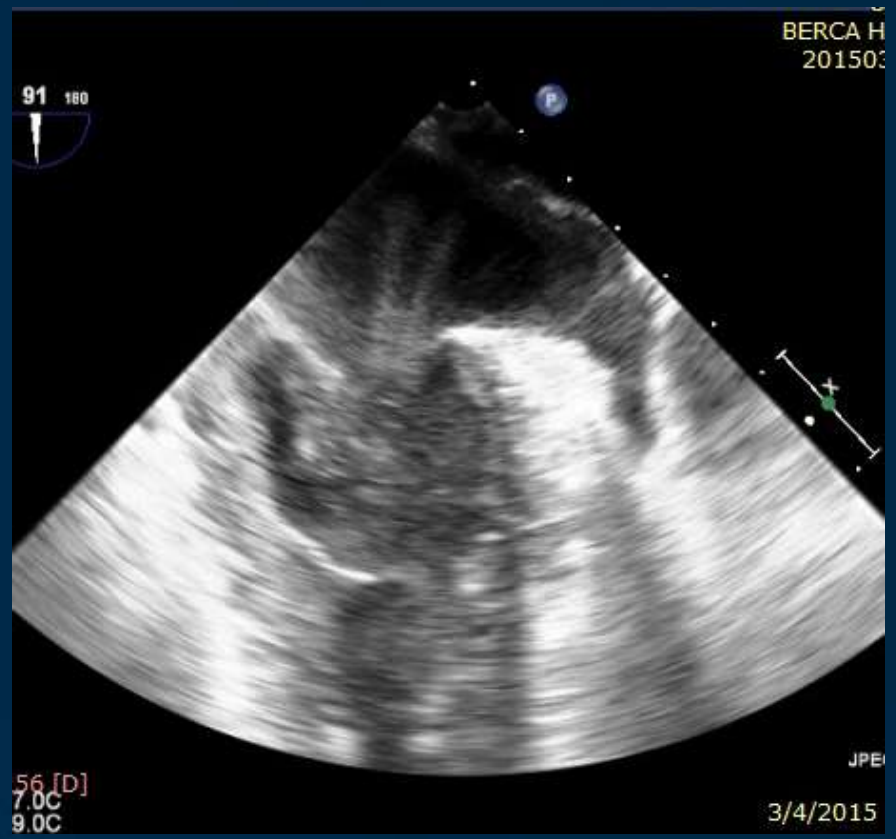
45 d F-up TEE, ***a big thrombus (T)*** was detected on the device.

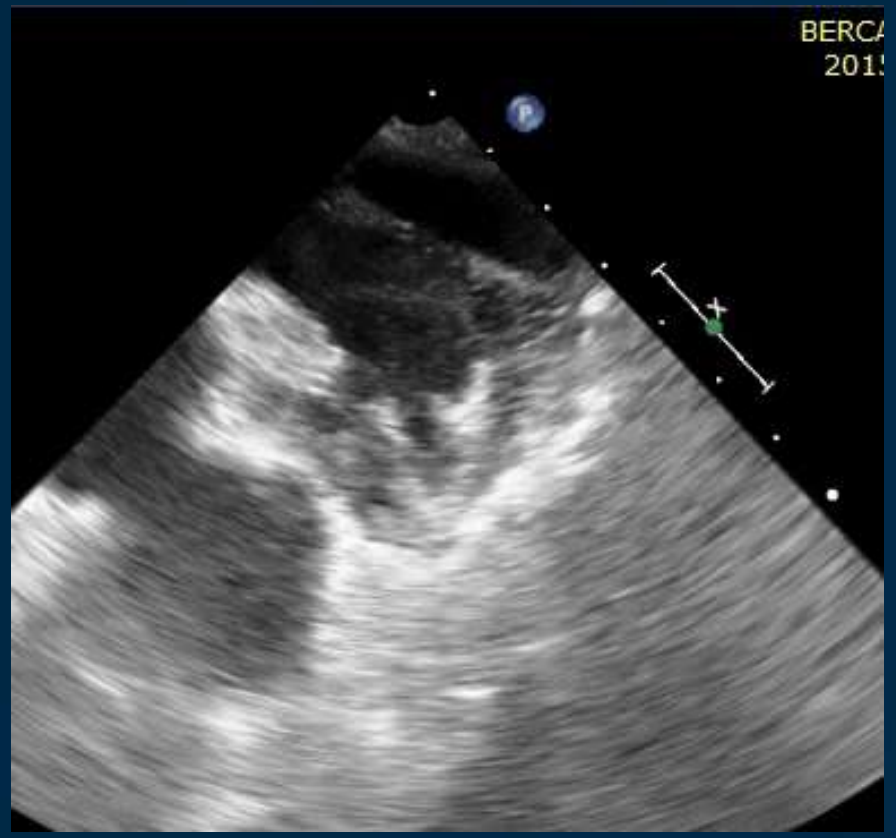
- ***Predisposing factors:***
  - Prior stroke, large LAA dimensions, permanent AF & those with previous LA thrombus[1]
- The relationship between DRT & long-term adverse CV events is unclear, but registry-based analyses have found an association between ***DRT & stroke/TIA during short-term f-up.***
- ***Anticoagulation*** should be continued

Saw J, et al. JSCAI. https://doi.org/10.1016/j.jscai 2022.100577; Available online 27 March 2023

Can LAA Occluder Be Implanted In Cases Like This ?

Would OAC NOAC or A Combination of LAA Occluder & OAC/NOAC Be A Better Choice ?





Conclusion

- Following procedure refinements & increasing operator experience, severe LAA closure complication rates have dropped significantly (< 1- 2%)
- Operators and the procedure team should always be vigilant and adept in recognition and deliver prompt treatment, especially if it is associated with signs of hemodynamic compromise.
- Prevention is better than treatment