# Relevant Anatomical Consideration to Prevent Complications of AF ablation

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# Korean Heart Rhythm Society

## COI Disclosure

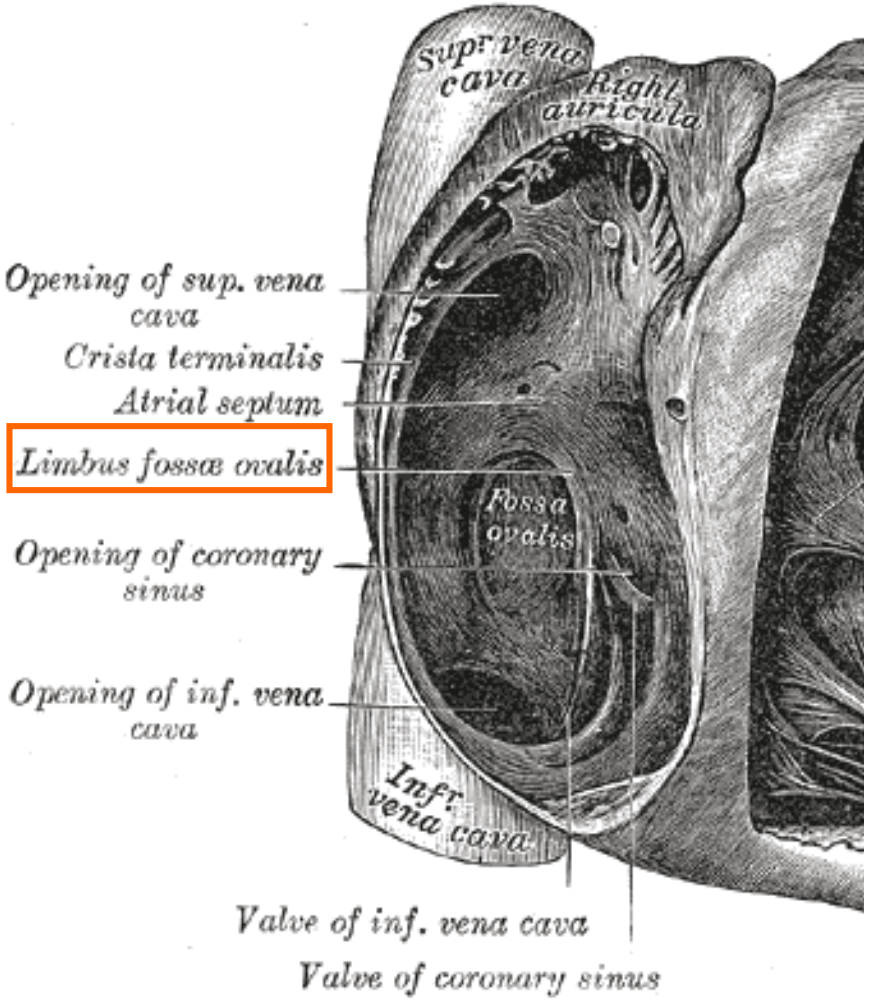
*Name of First Author: Hsuan-Ming Tsao*

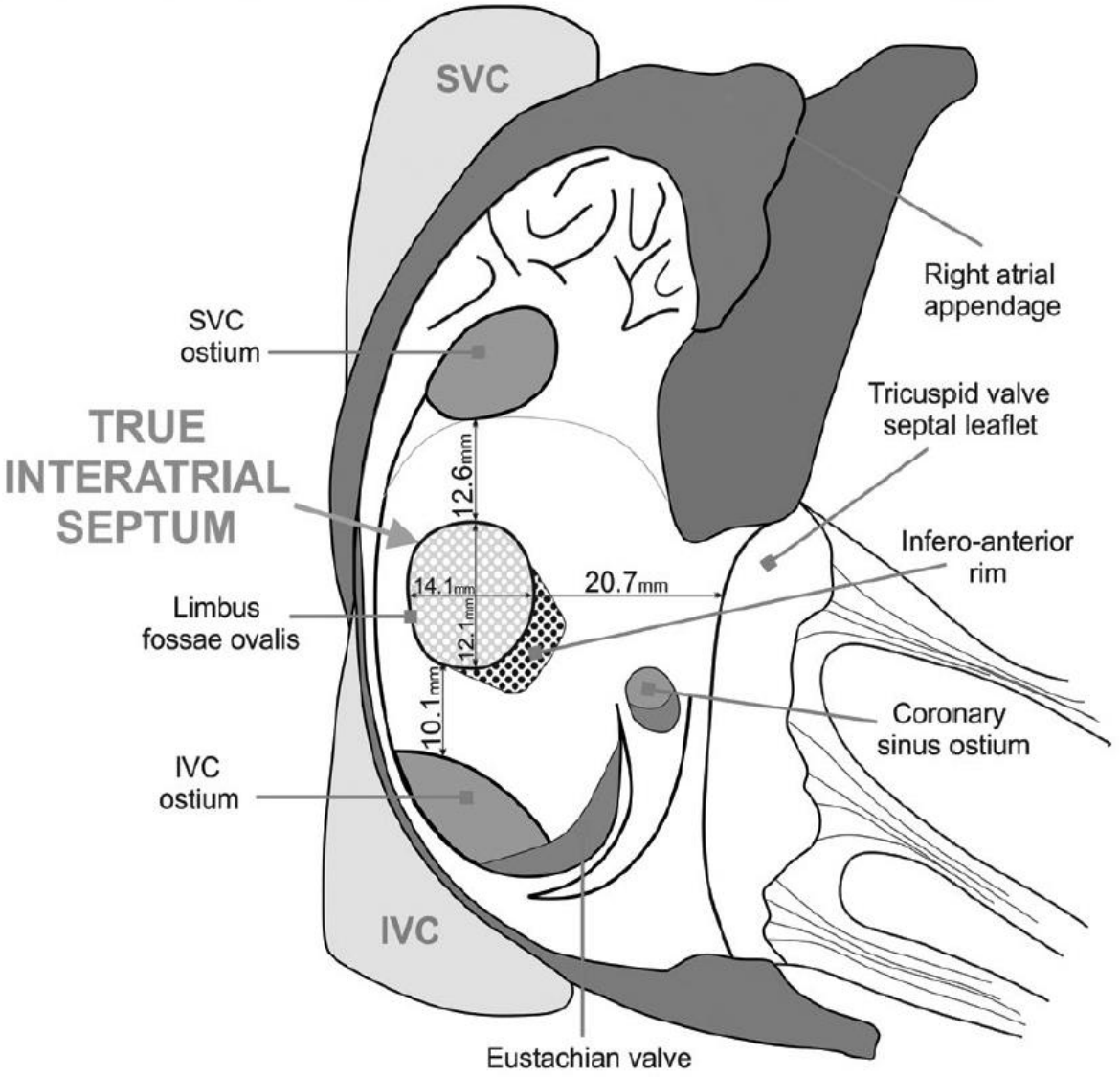
The authors have no financial conflicts of interest to disclose concerning the presentation

# Outlines

- **Inter-atrial septum** and transseptal procedure
- **Pulmonary veins** stenosis after catheter ablation
- Vulnerable **LA** anatomy
- **Adjacent structures** warrant attention to prevent collateral damages

# Inter-Atrial Septum

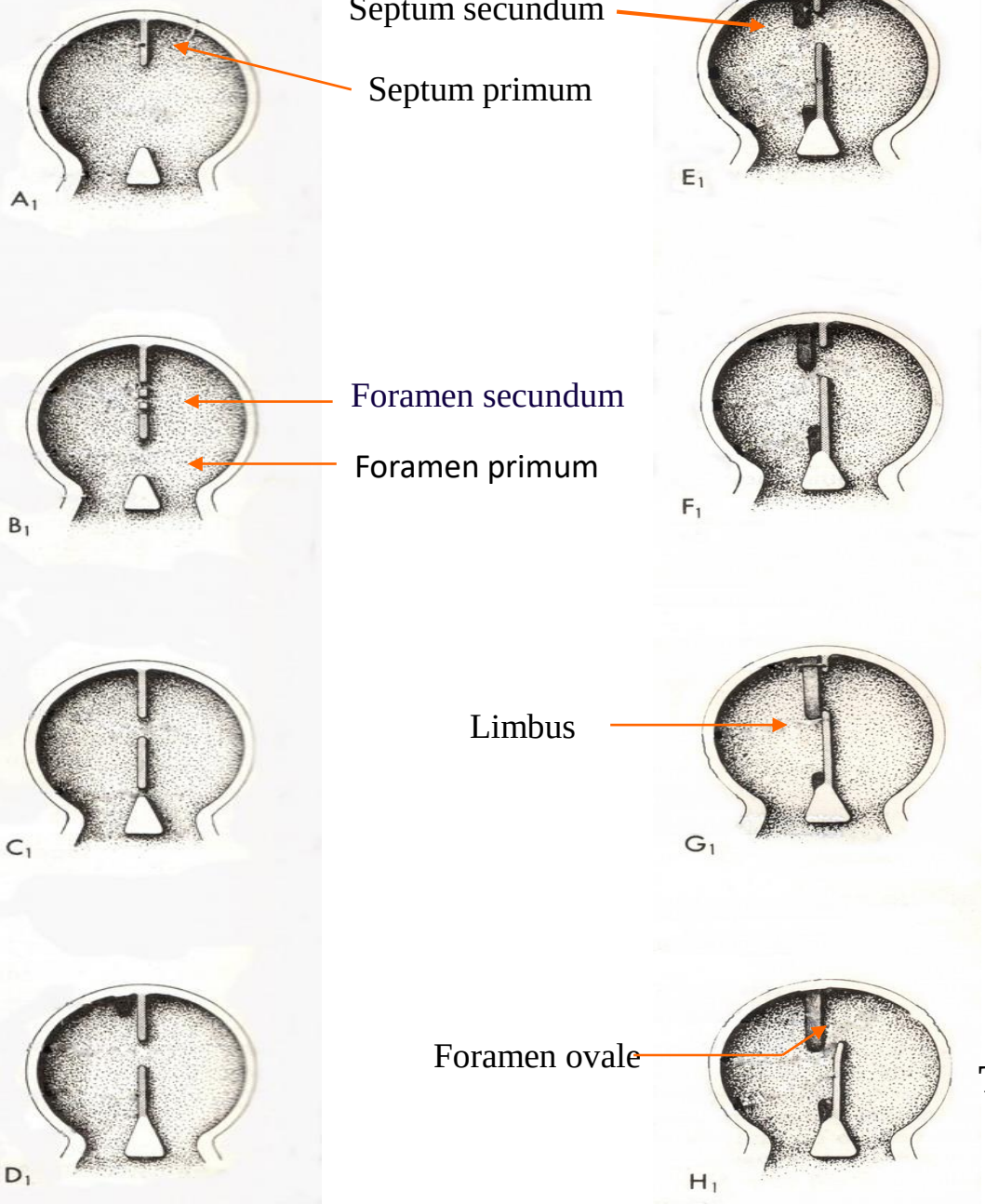



Old Atlas of Heart

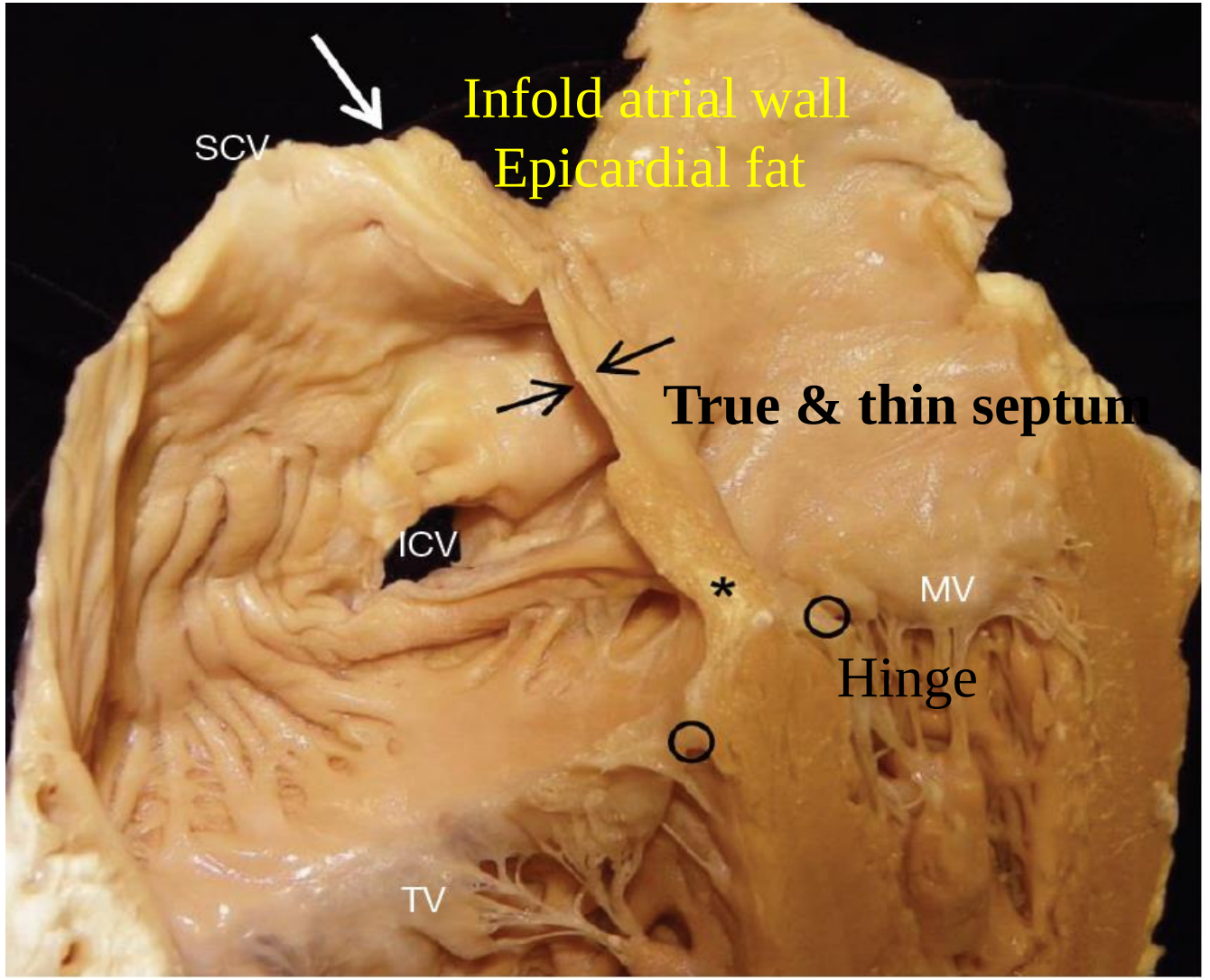
Klimek-P W et al Ann Anat 2016

# *Development of Interatrial Septum*



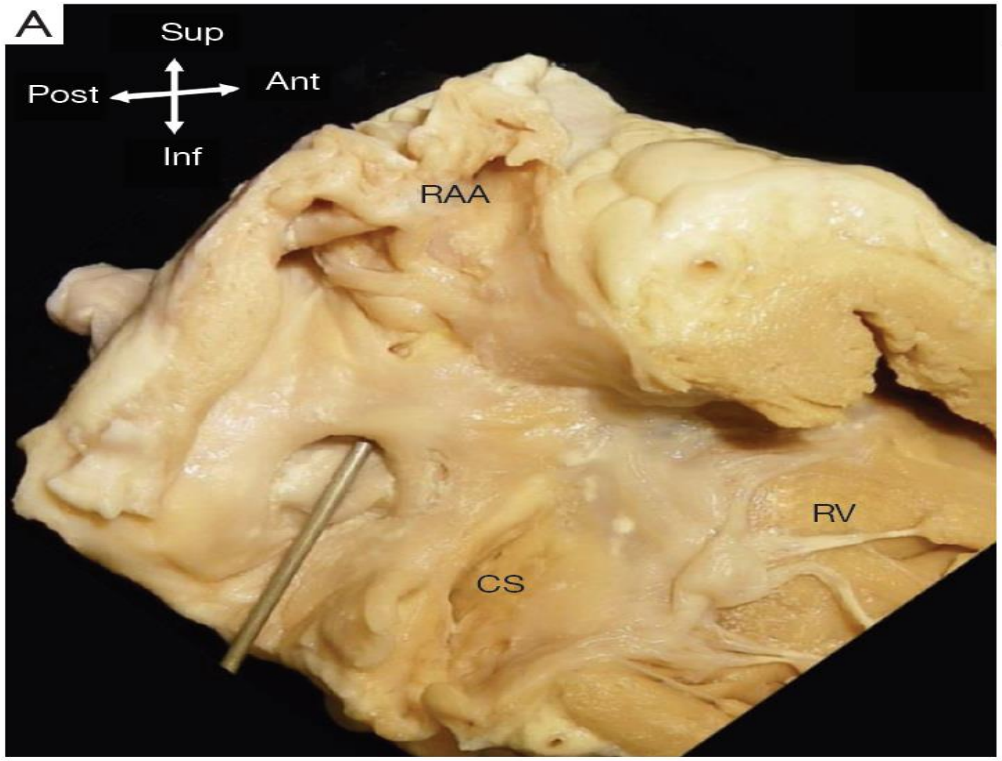

Moore KL.
**The developing Heart.** Third edition

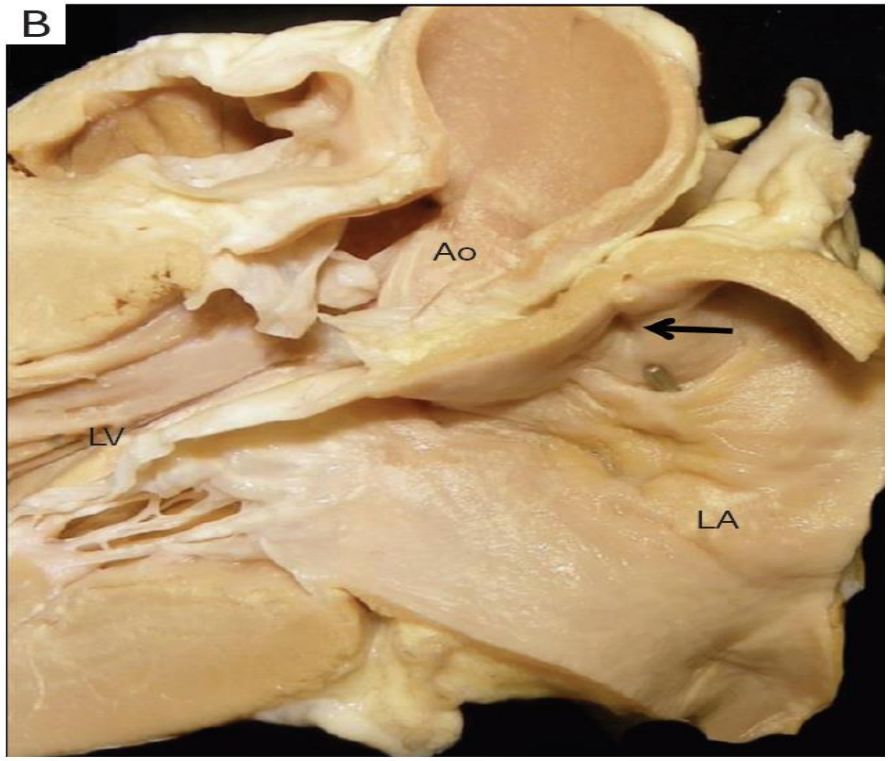
KHRS 2023




1. Four chamber plane showed thin area bordered by thicker muscular rim
2. Superior : infold atrial wall with adipose tissue.
   Inferior: septum with epicardial fat

# Location of Patent Foramen Ovale (PFO)





1. Incidence of PFO~ 25-34%
2. PFO is at the anterior-cephalad margin of fossa
3. Probe directed to the anterior wall of LA, just behind aorta!!

***SY Ho JTD 2018***

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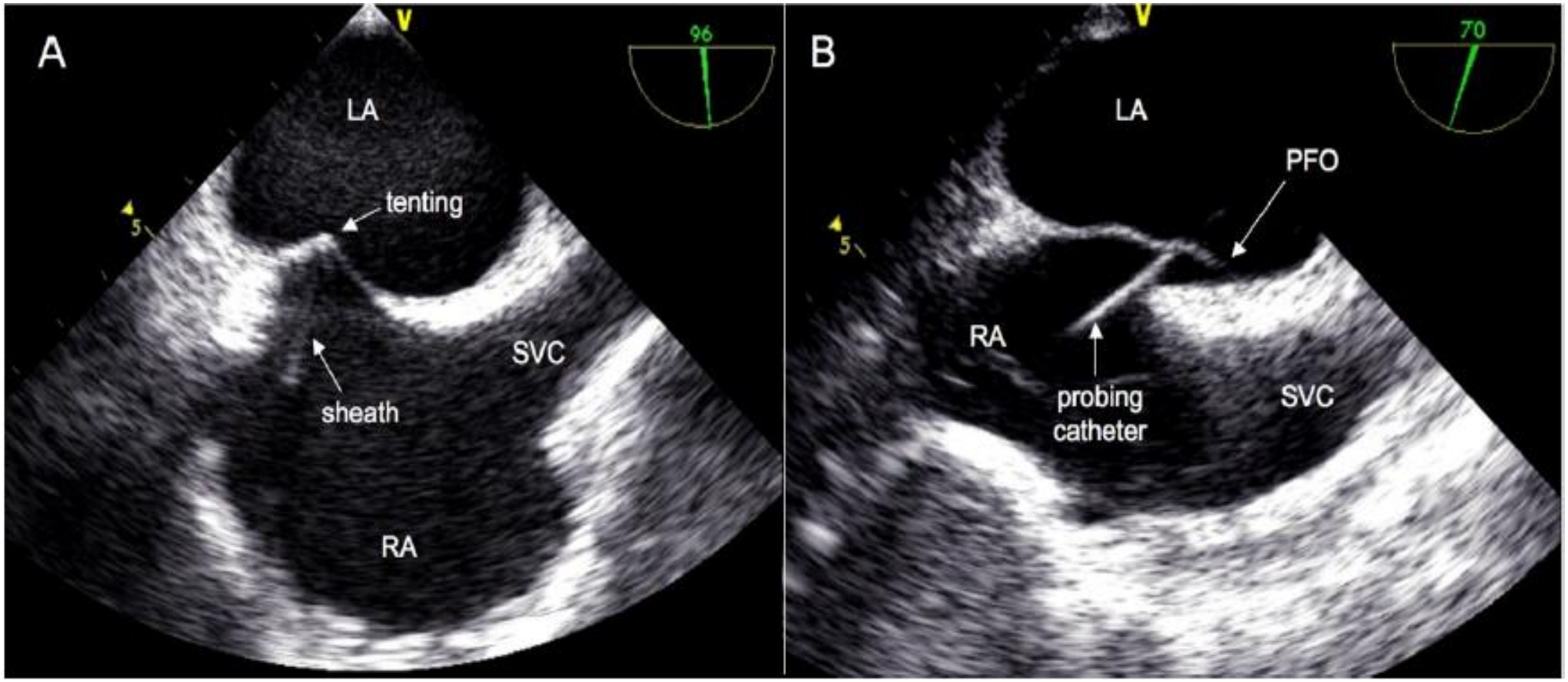
# **Transseptal Access for Left Atrial Ablation:** The Catheter-Probing Techniques Are Not Without Risk




Typical transseptal position

Cather probing through PFO

**Lehrmann et al JCE 2014**

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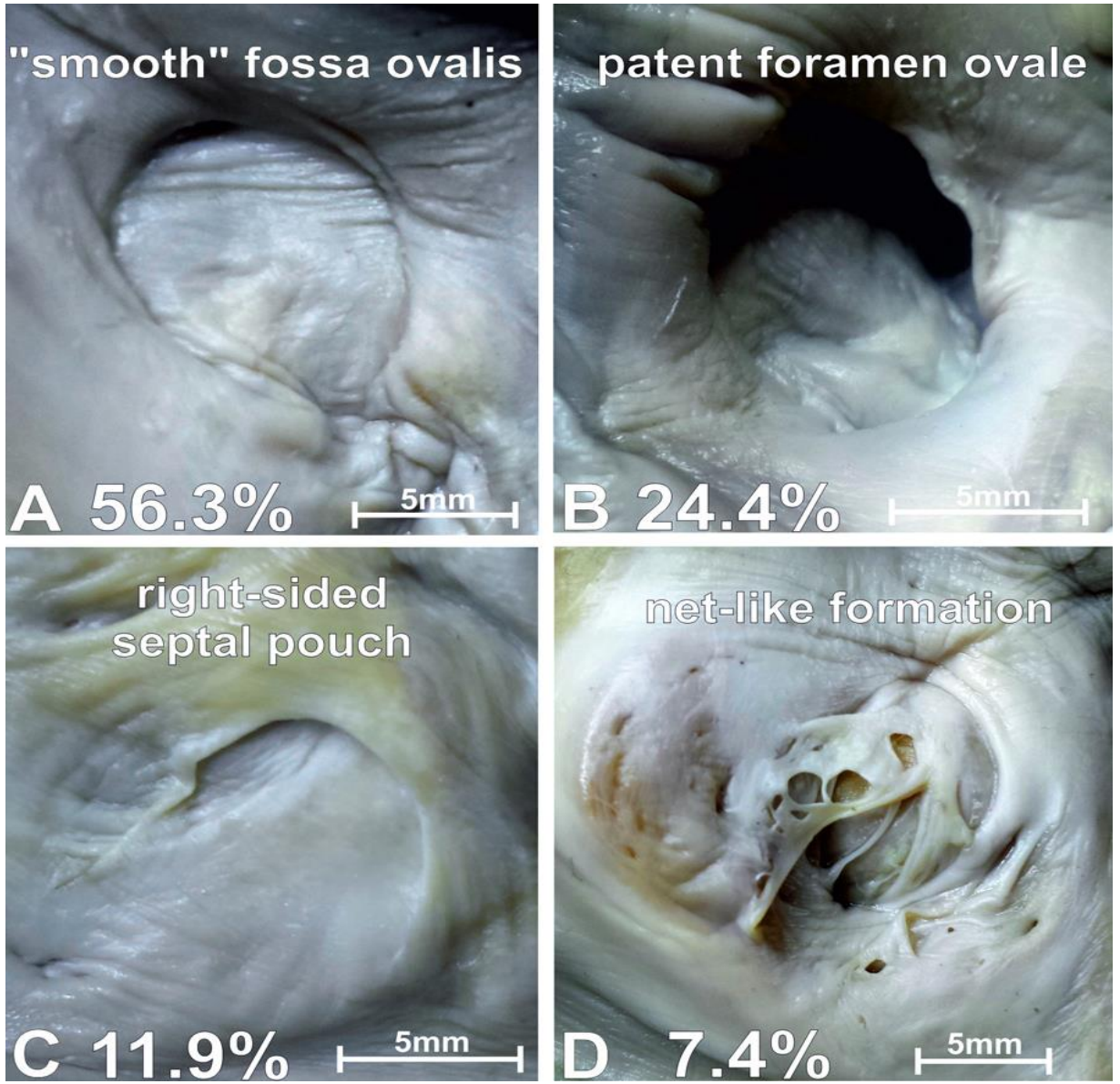
# Different morphologies of fossa ovalis




135 autopsied Heart

28% female

19-94 years old

Klimek-Piotrowska et al **Annals of Anatomy 2016**

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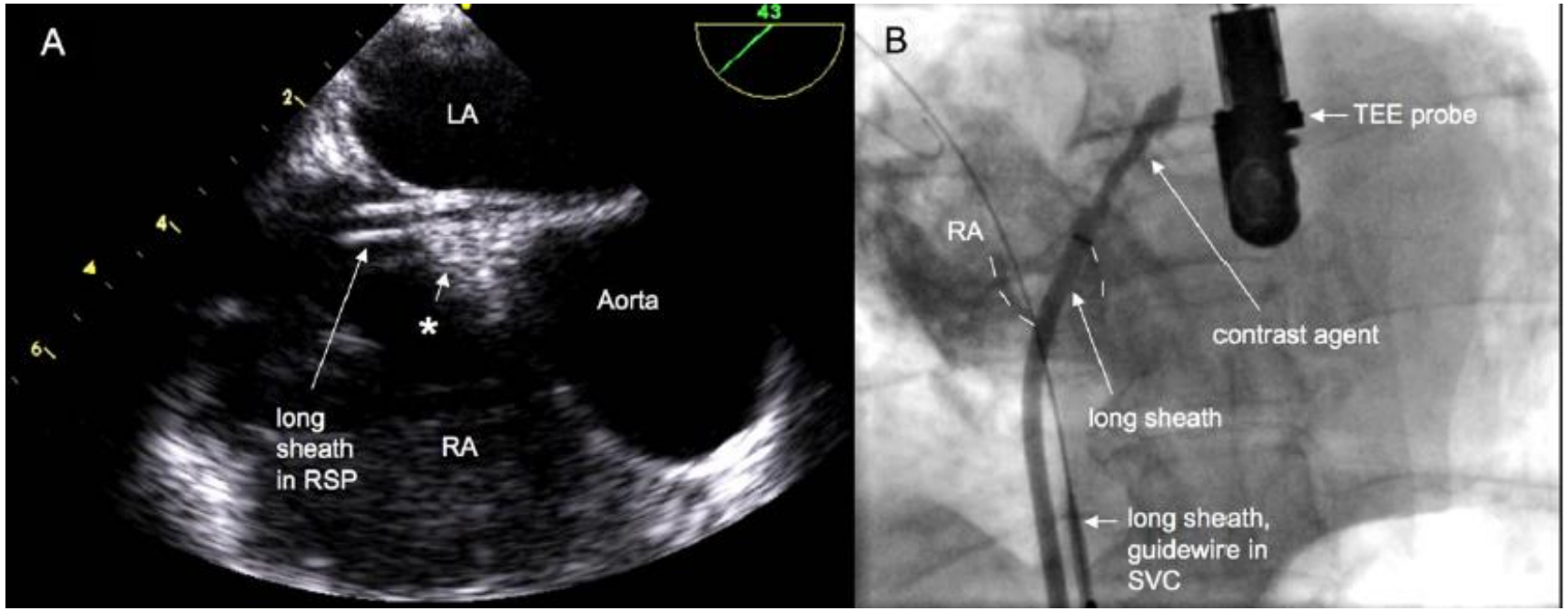
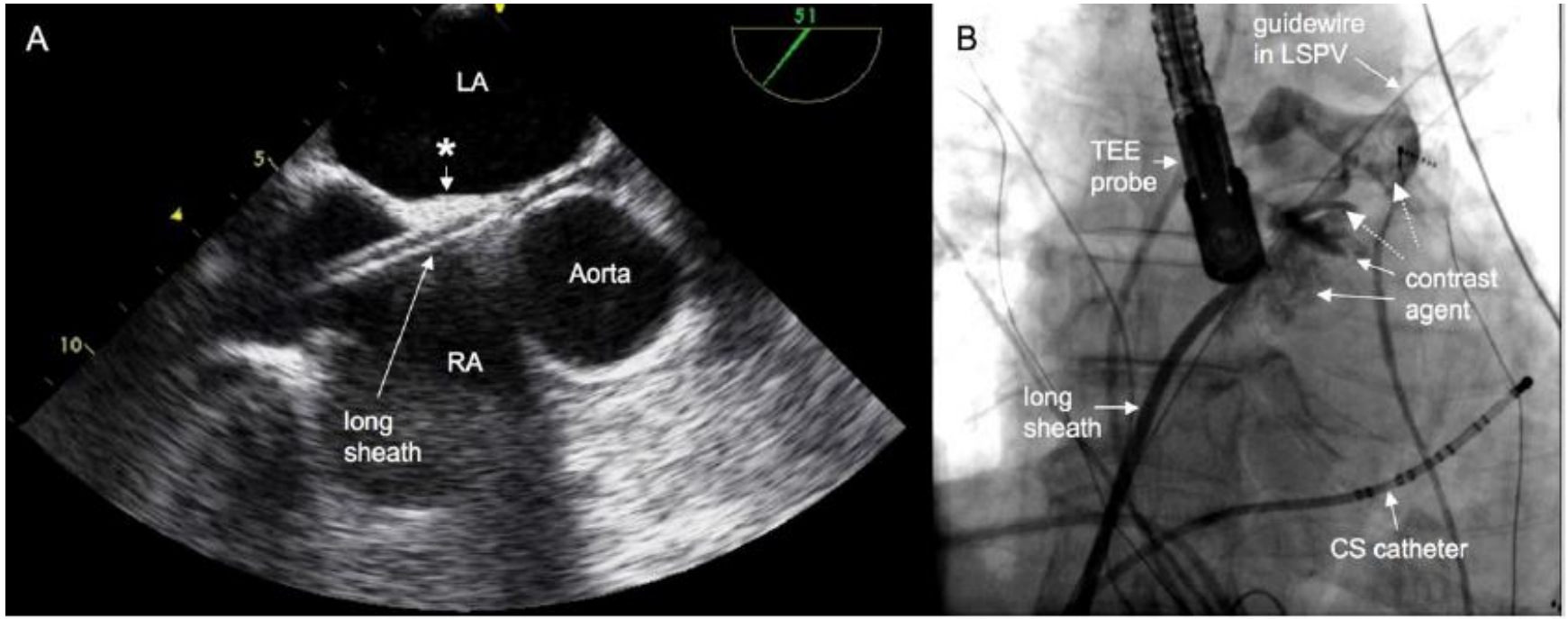
# Atrial septal dissection




1. Dissection of IAS from inside fossa ovalis
2. The long sheath was thin FO and thicker muscular rim (*)
3. Typical vertical contrast-staining in the fluoroscopic view

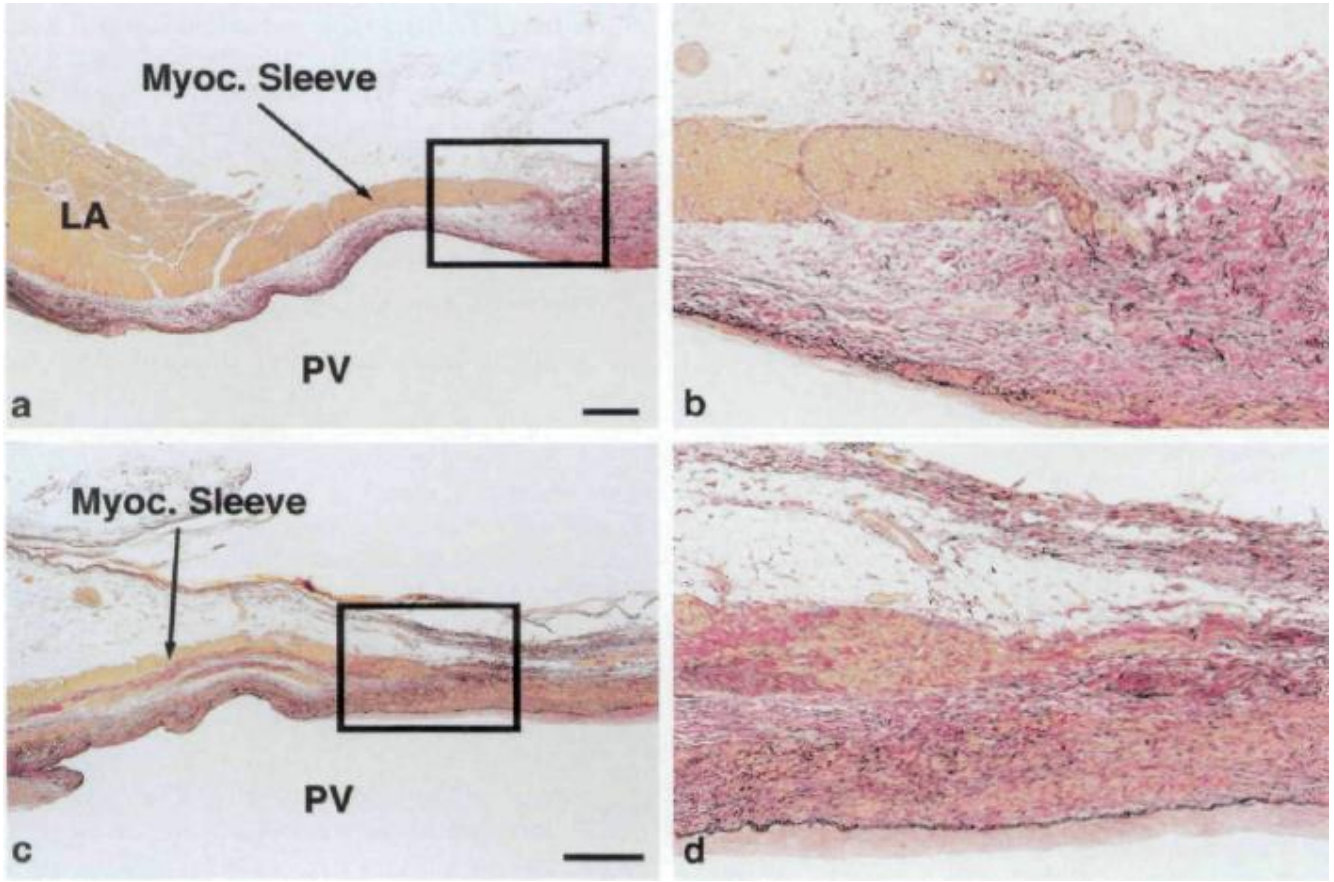
# Atrial septal perforation

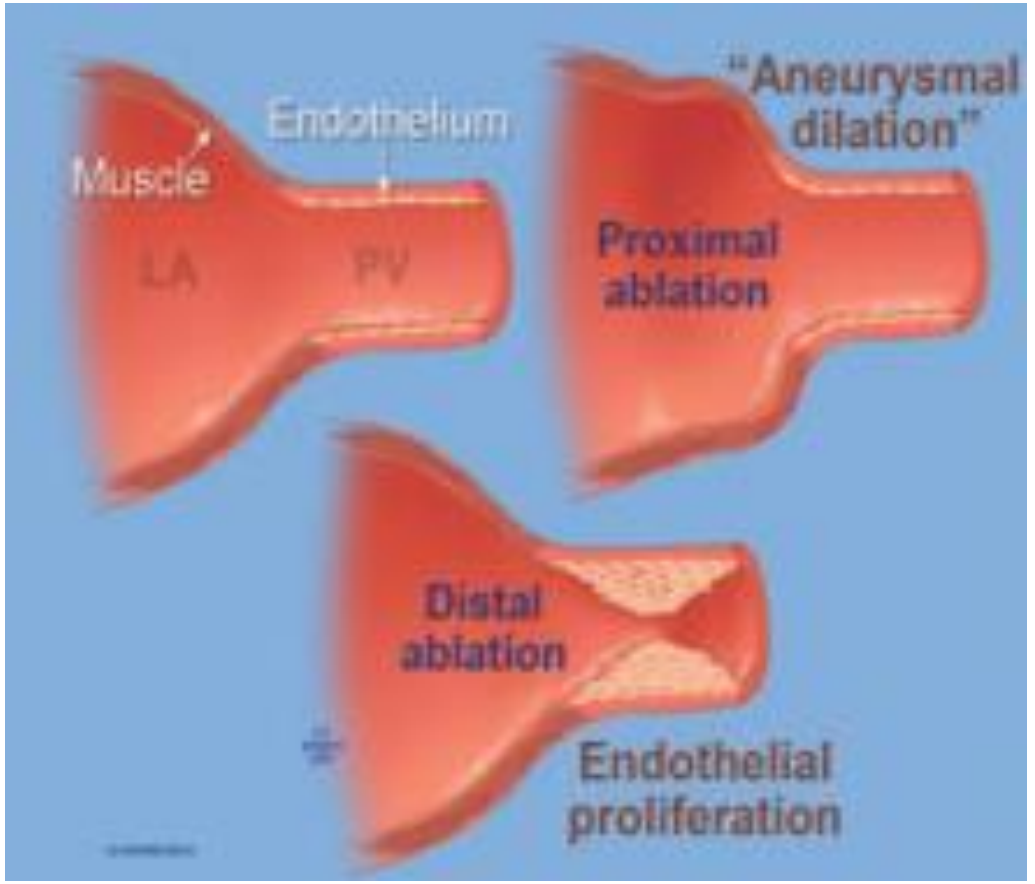



1. Direct perforation through the muscular rim above the FO
2. Diffuse contrast staining along the perforating canal and staining in the pericardial space (dashed arrow lines)

# Pulmonary veins

# Myocardial sleeve in pulmonary veins




**Saito T JCE 2000**

Macedo JCE 2010

# Ablation related PV stenosis

**Severe PVS Symptoms**

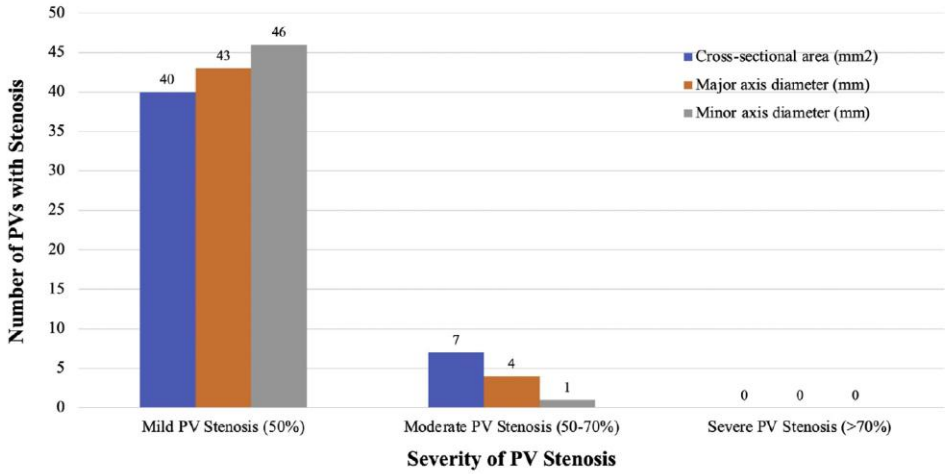
Shortness of breath (46%, n=24)
Decrease in exercise (42%, n=22)
Cough (25%, n=13)
Chest pain (9%, n=5)
Hemoptysis (5%, n=3)

**Study Population**
**2000-2015**
52 of 10368 (0.5%) patients with severe PV stenosis from prior AF ablation ( total of 63 veins)

**Severe PVS distribution**

51% LSPV
36% LIPV
6% LCPV
5% RIPV
2% RSPV

**Raeisi-Giglou et al Circ AE 2018**




*A total of 47 PVs had stenosis: 5 had moderate and 42 mild PV stenosis.

| Pulmonary vein | Cross-sectional area OR (95% CI), P value |
|---|---|
| Common ostium (n = 21) | 0.79 (0.24-2.56) $P = 0.69$ |
| RSPV (n = 143) | 1.74 (0.72-4.21) $P = 0.22$ |
| RIPV (n = 143) | 0.97 (0.33-2.85) $P = 0.95$ |
| LSPV (n = 122) | 0.78 (0.17-3.44) $P = 0.74$ |
| LIPV (n = 22) | 0.36 (0.12-1.02) $P = 0.06$ |

**Advice trial Can J Cardiol 2020**

# Location of LA Appendage and Extension of Interposed Ridge

## Superior LAA

*AF:33%*

*SR:22%*

## long ridge

*AF:71%*

*SR:82%*

## Horizontal LAA

*AF: 38%*

*SR:64%*

## short ridge

*AF:29%*

*SR:18%*

## Inferior LAA

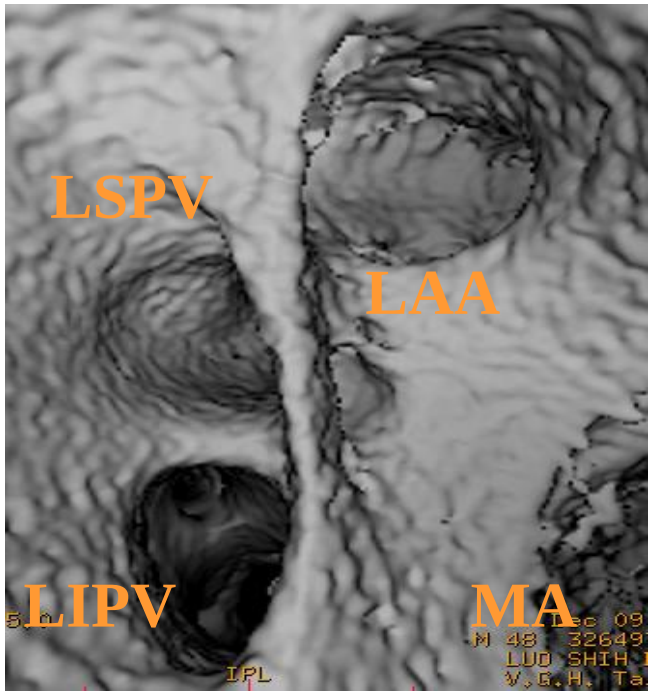
*AF:29%*

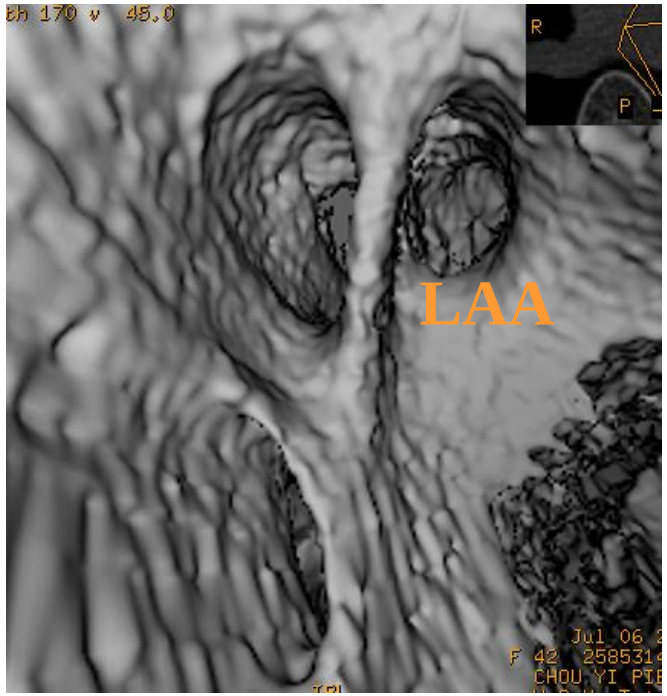
*SR:14%*

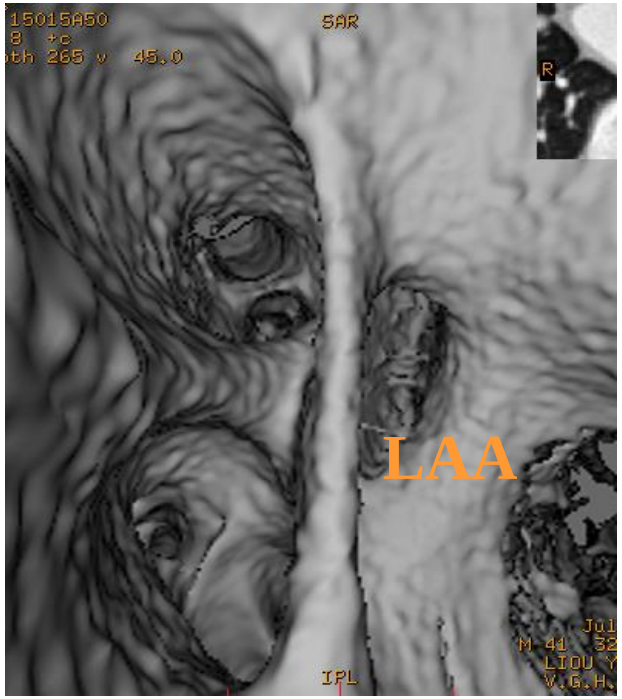
## long ridge

*AF:71%*

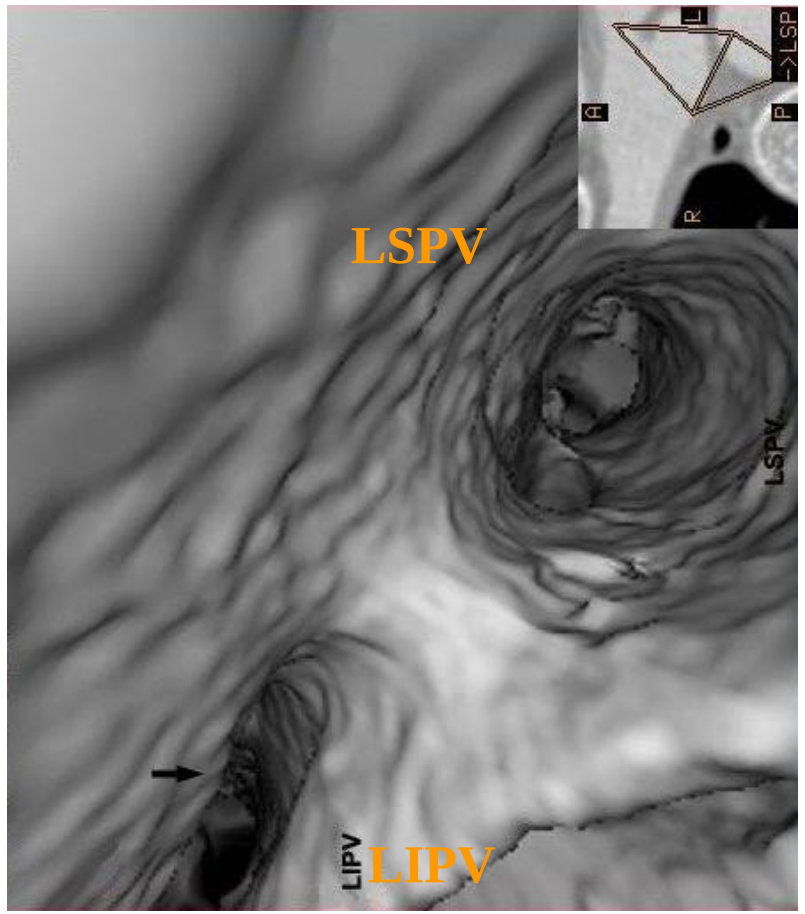
*SR:82%*



# Pre-existed PV stenosis


Preexisting PV stenosis, 2.8%

(1) External compression by aorta

(2) Focal stenosis

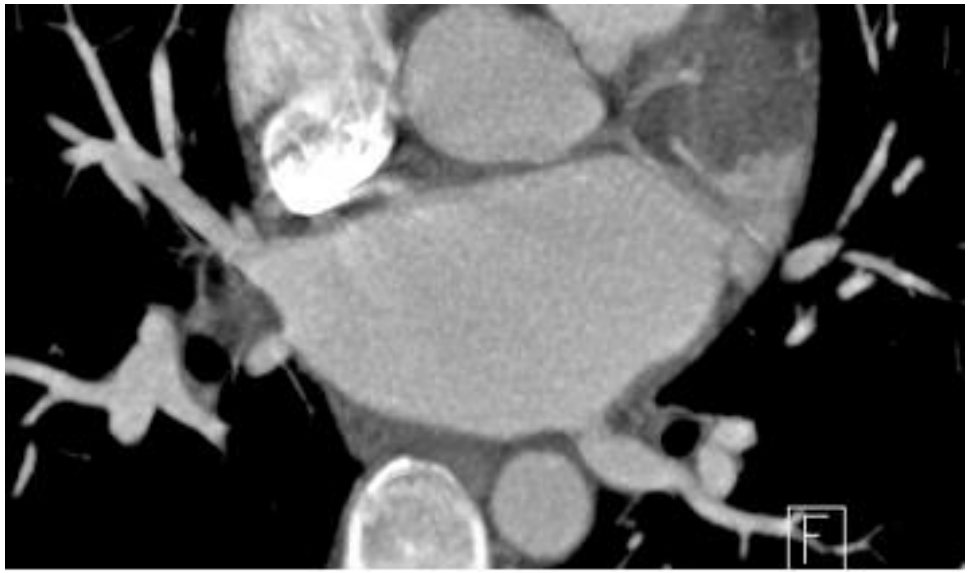
Wongcharoen /Tsao JCE 2005

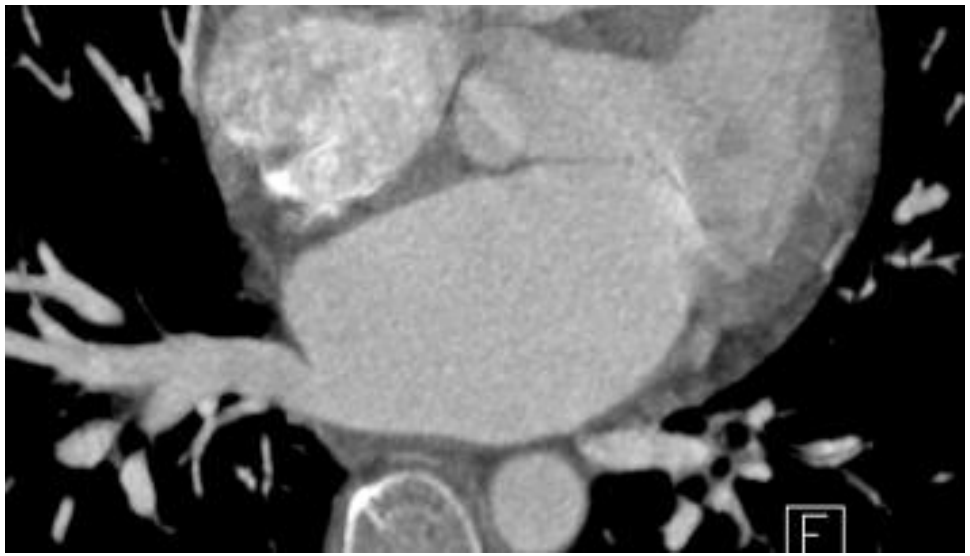
# PV variation

| | |
|---|---|
| **Supernumerary PVs** | |
| Right | 18-29% |
| Left | 3% |
| **Common Ostium of** | |
| Right PVs | <1% |
| Left PVs | 3-35% |
| **Early branching of right inferior PV** | 66-99% |
| **“Right top” PV** | 3% |

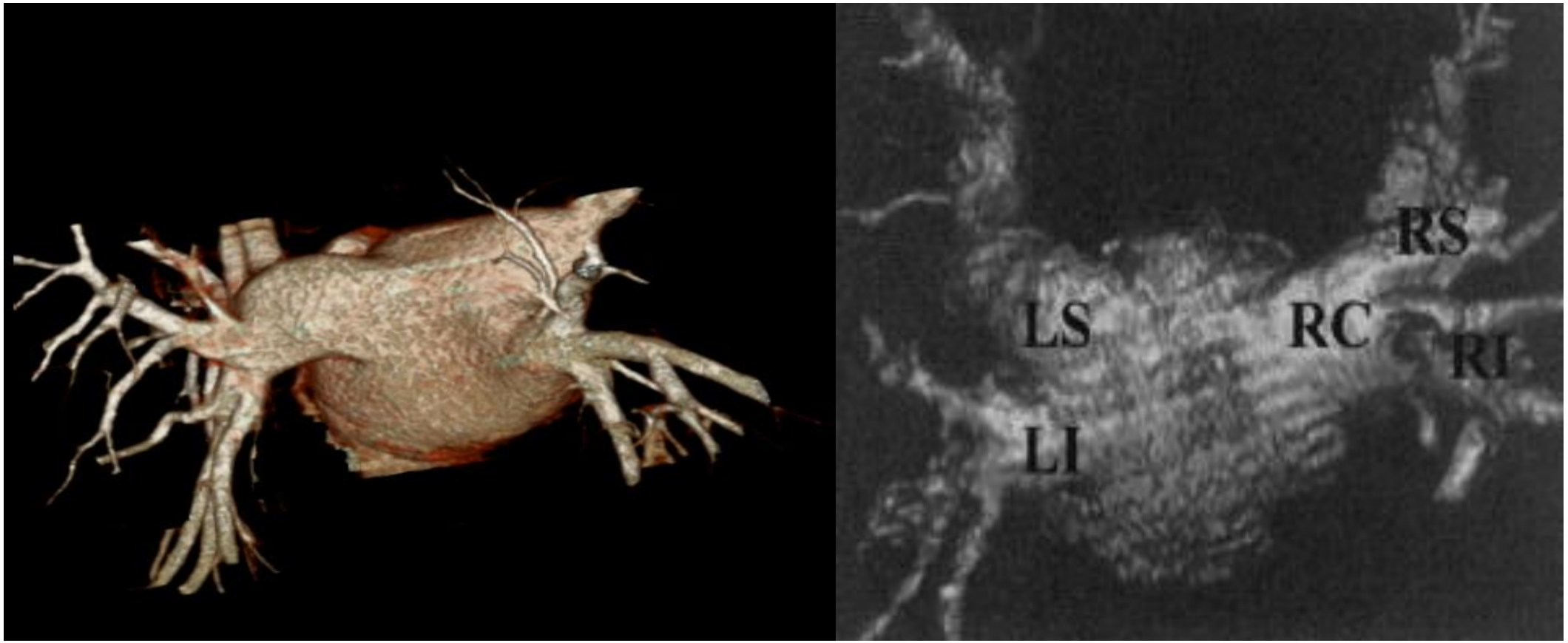
Tsao and Chen JACC 2006

# Supernumerary right PVs

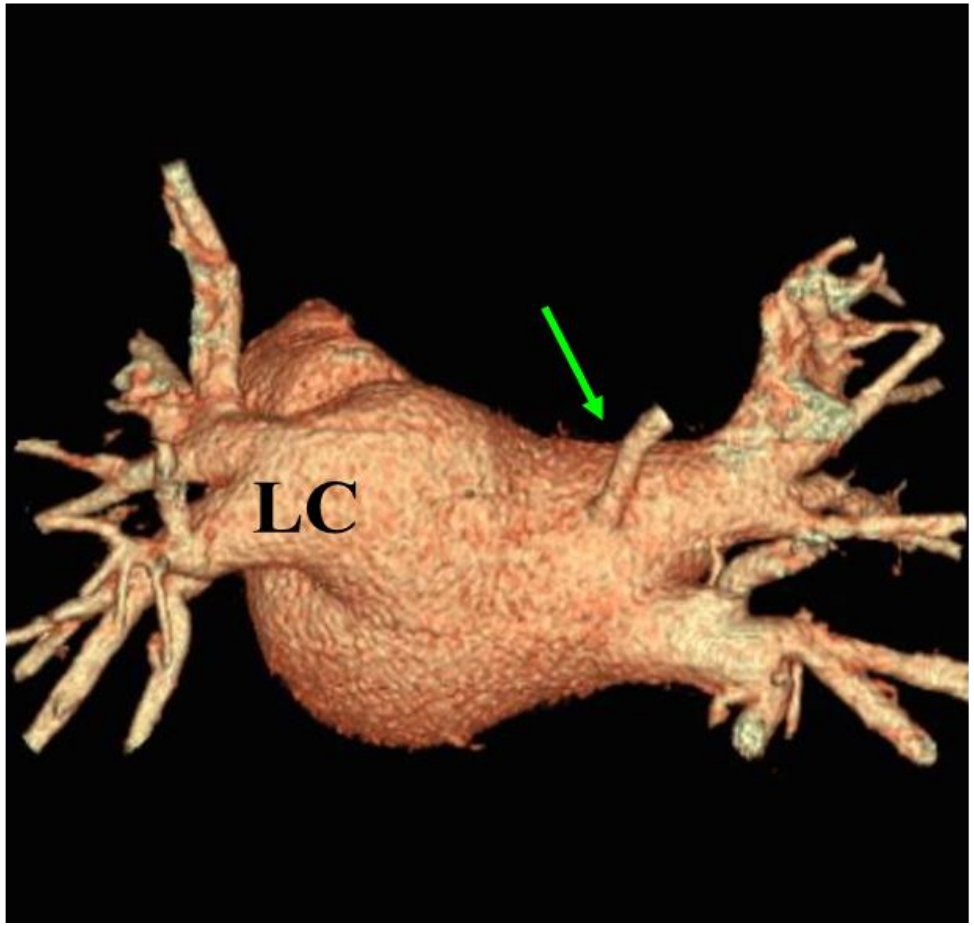



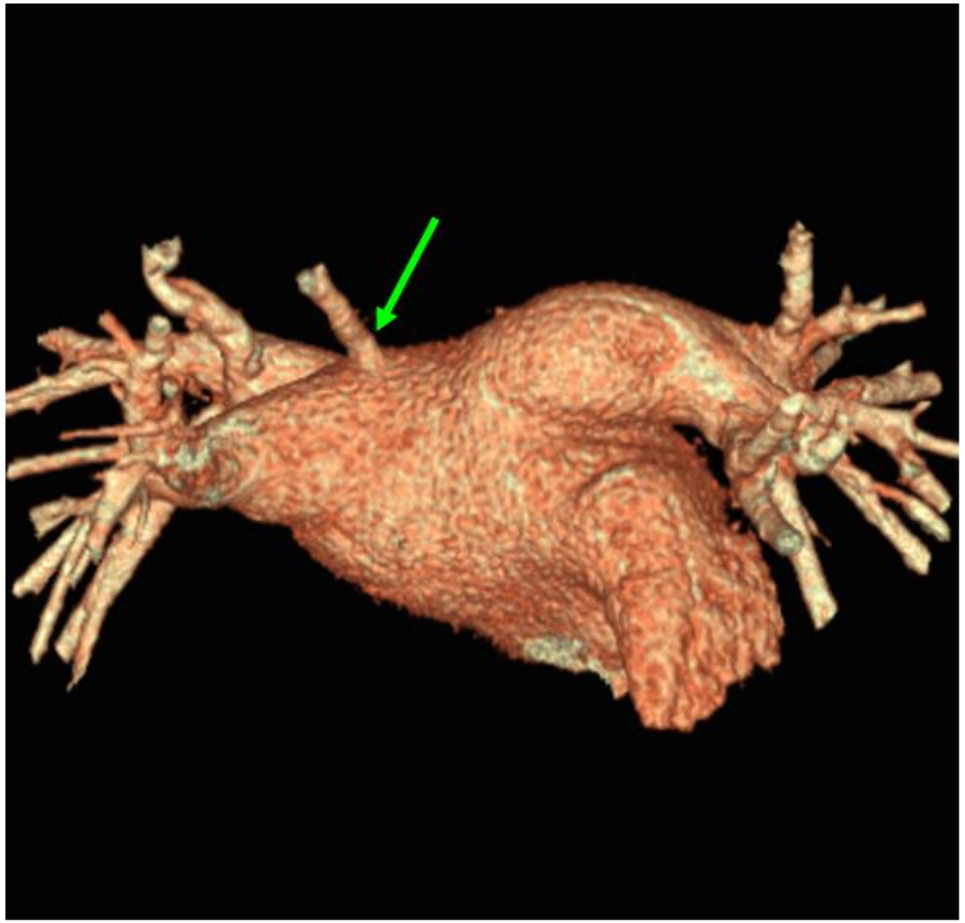



# Left and right PV common trunk



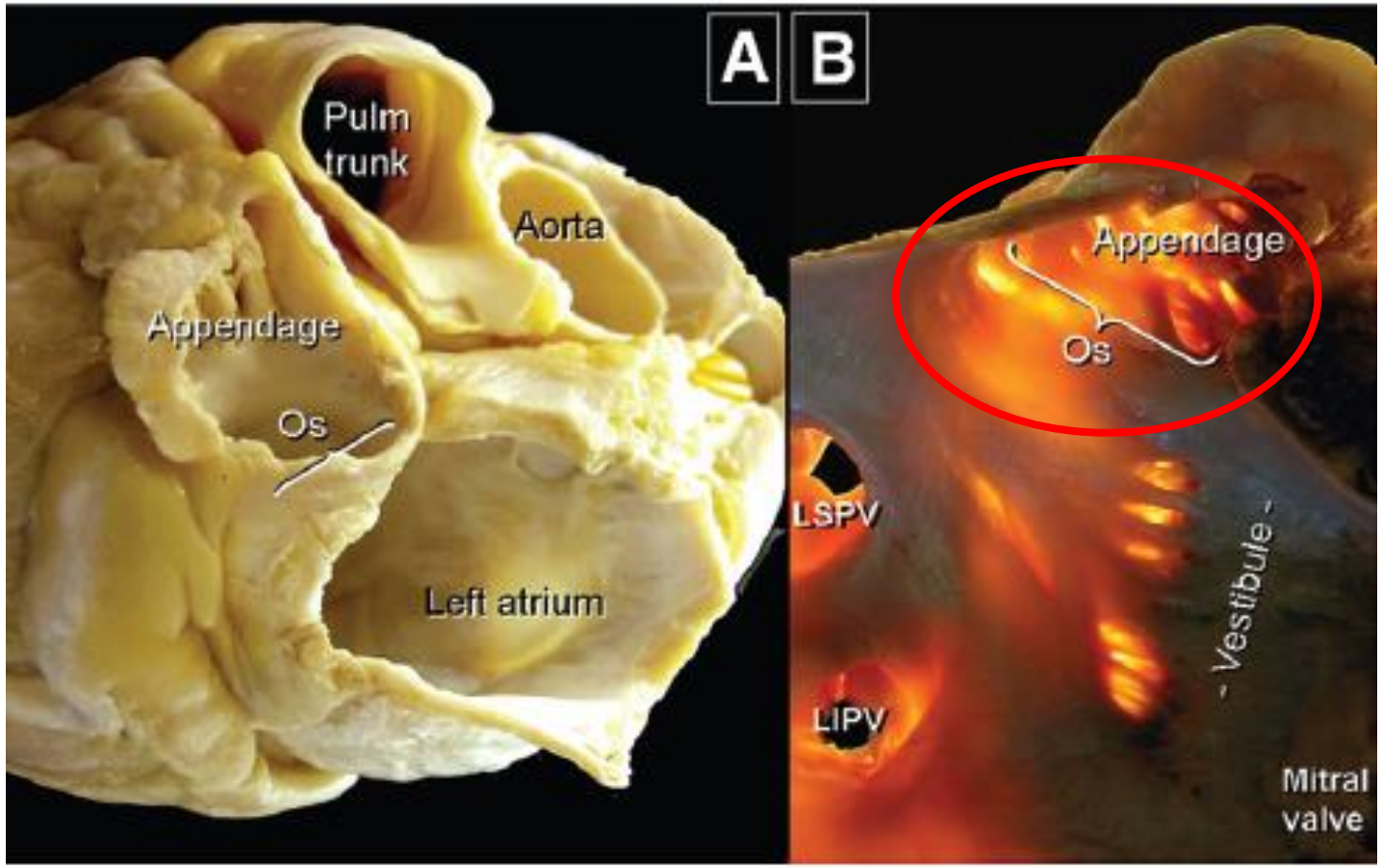
# Right Top PV and Left Common Trunk



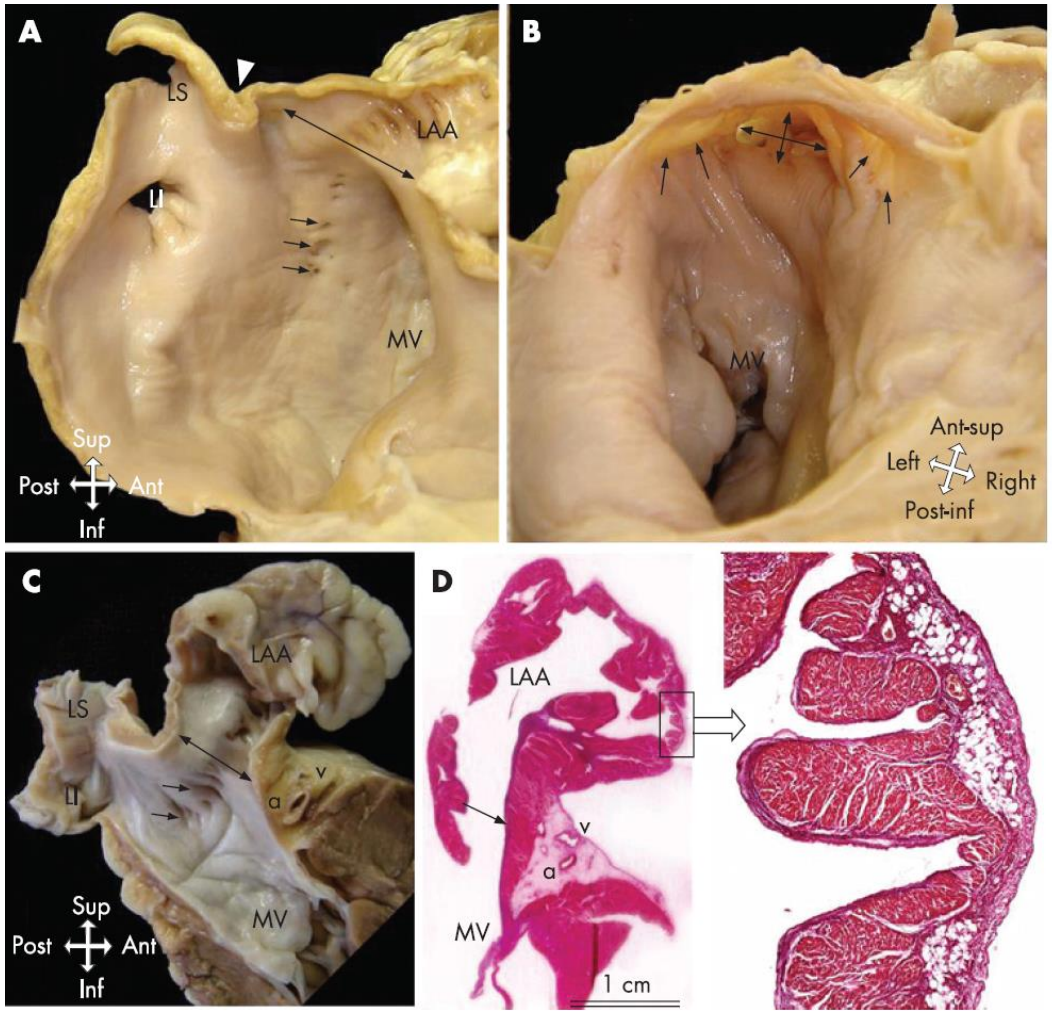
# Vulnerable LA anatomy

# Various wall thickness of LA




The thinness of appendage wall and the atrial wall in vicinity of OS

# Small fold and cluster of pits between LA and LAA




**Su and Ho Heart 2008**

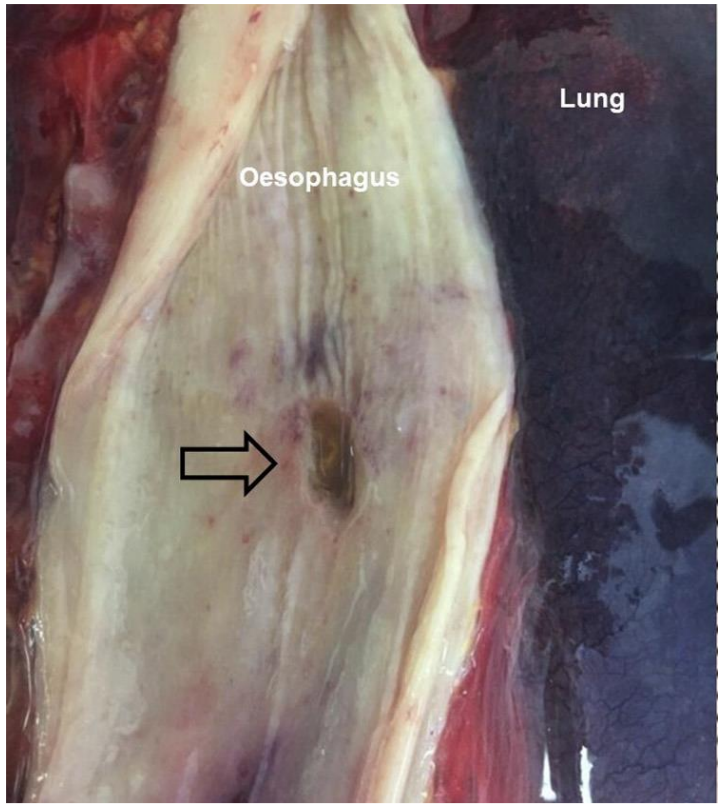
KHRS 2023

# Adjacent structures

# Atrio-esophageal fistula

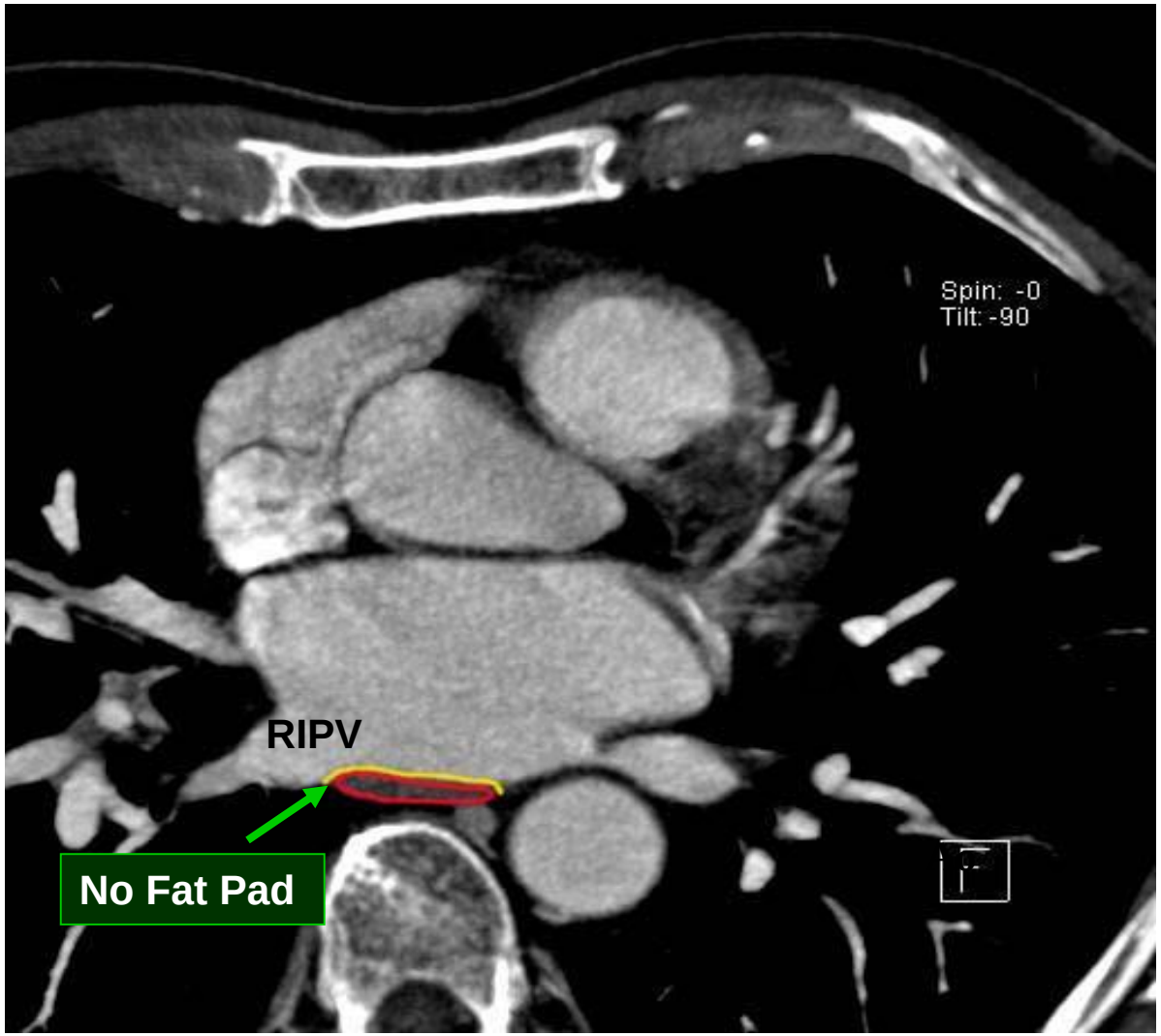
Rare (0.1-0.3%) but very high mortality 60-80%


**Pappone et al Circulation 2004**

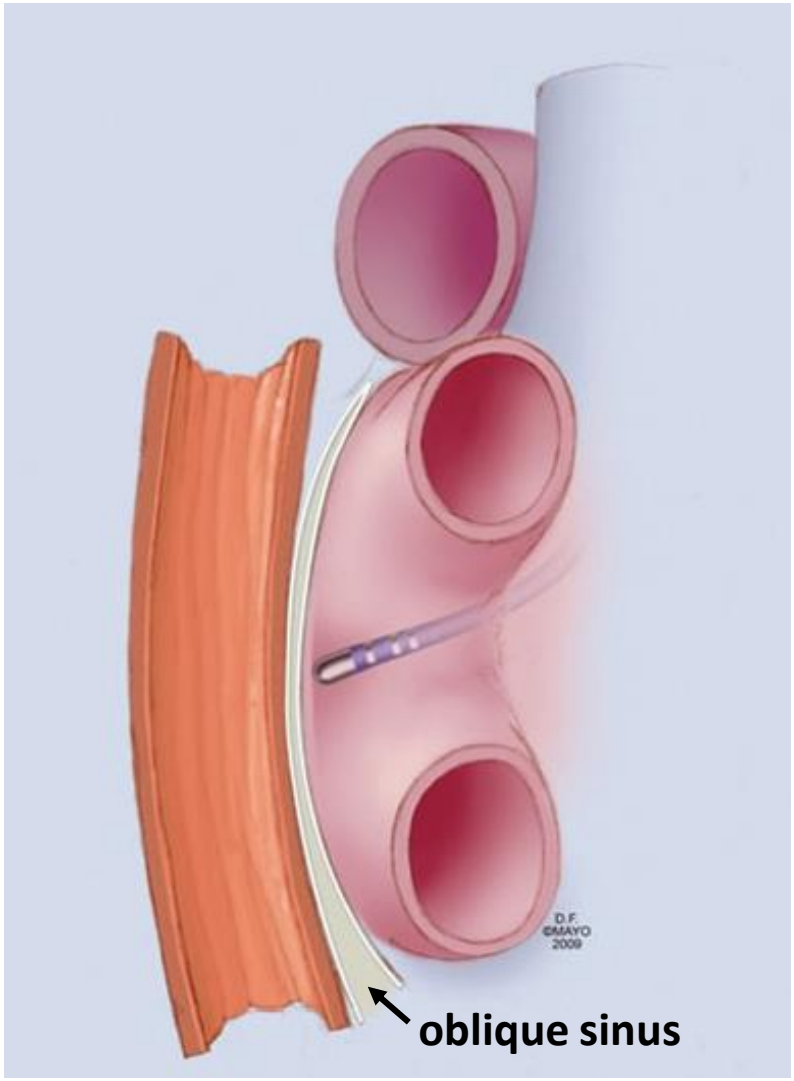



Leung et al Heart Rhythm O2 2021

# Close contact of esophagus and posterior LA



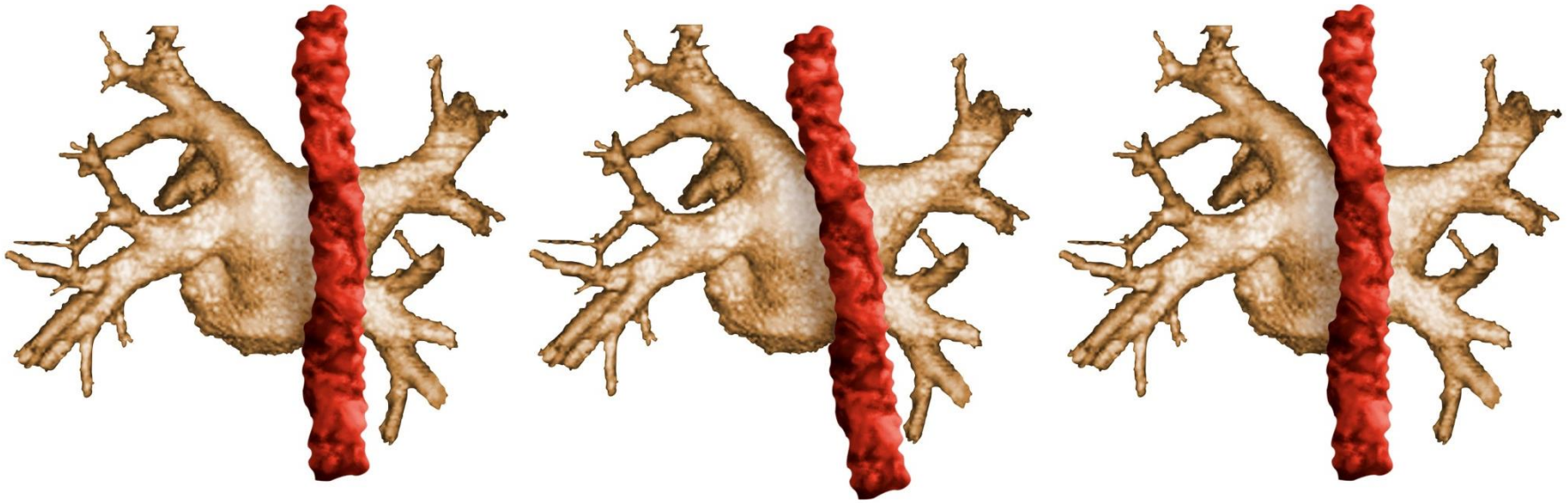

Tsao/Chen Chest 2005




Macedo JCE 2010

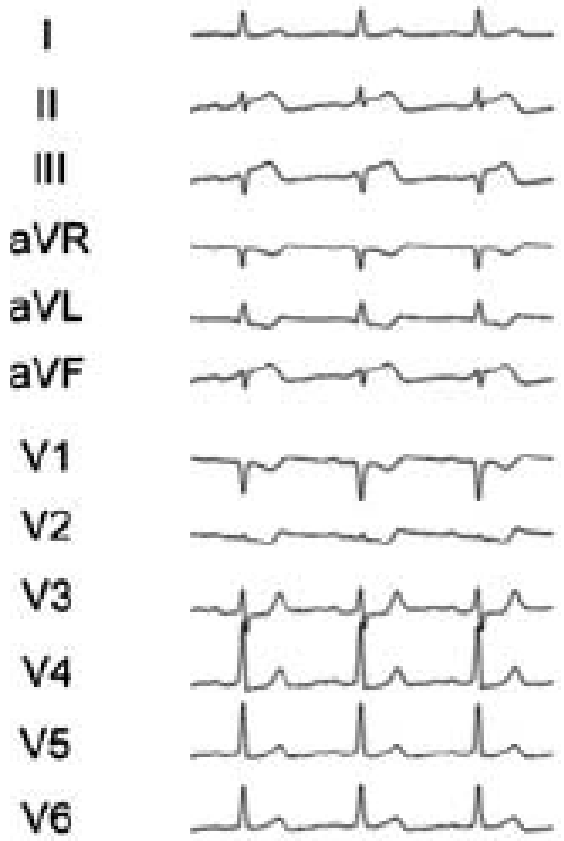
# *Various and motile course of esophagus*

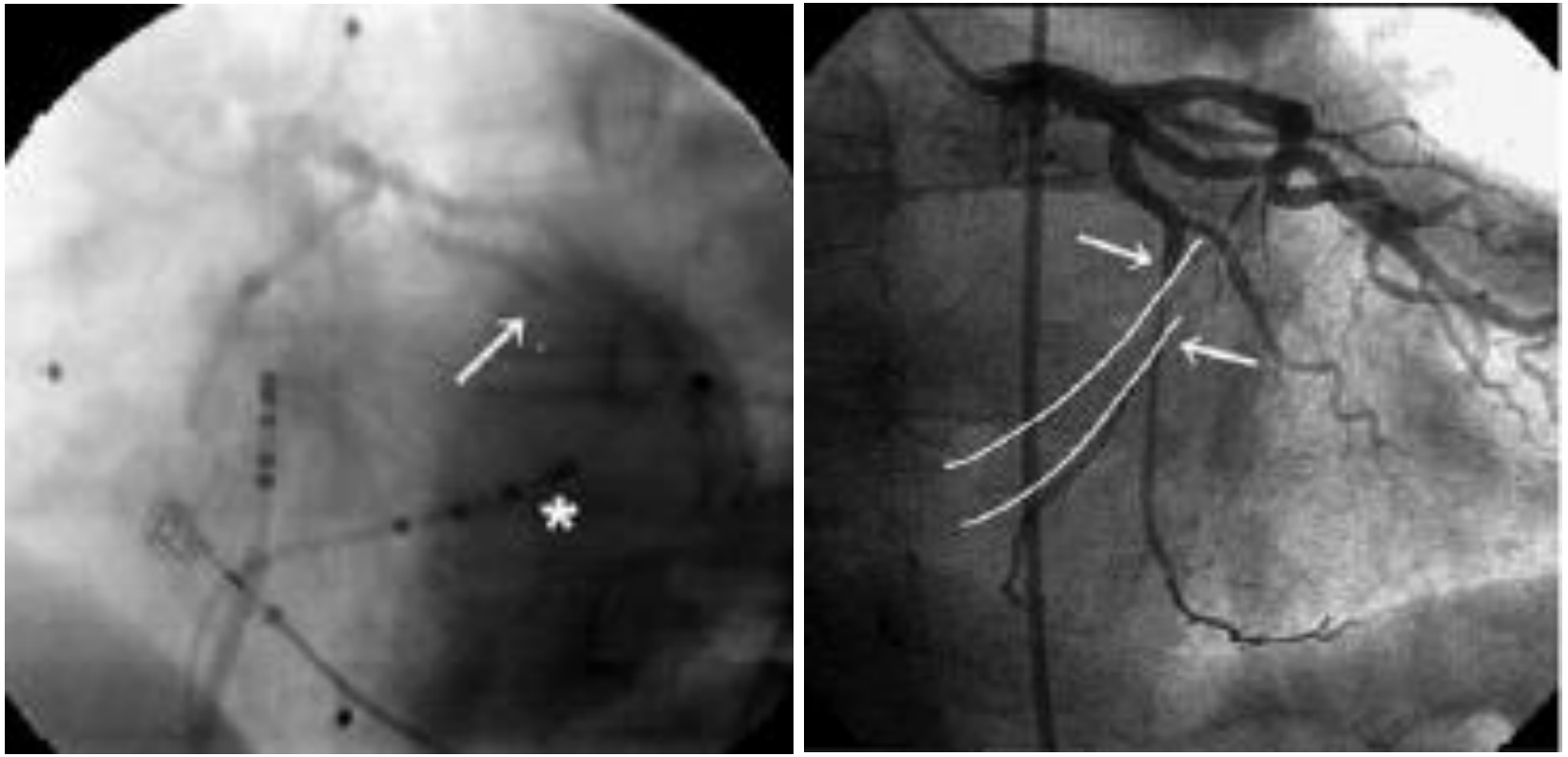
A B C



**Real time monitoring? Temperature monitoring?**

# AMI during mitral isthmus ablation through CS



Takahashi el at JCE 2005

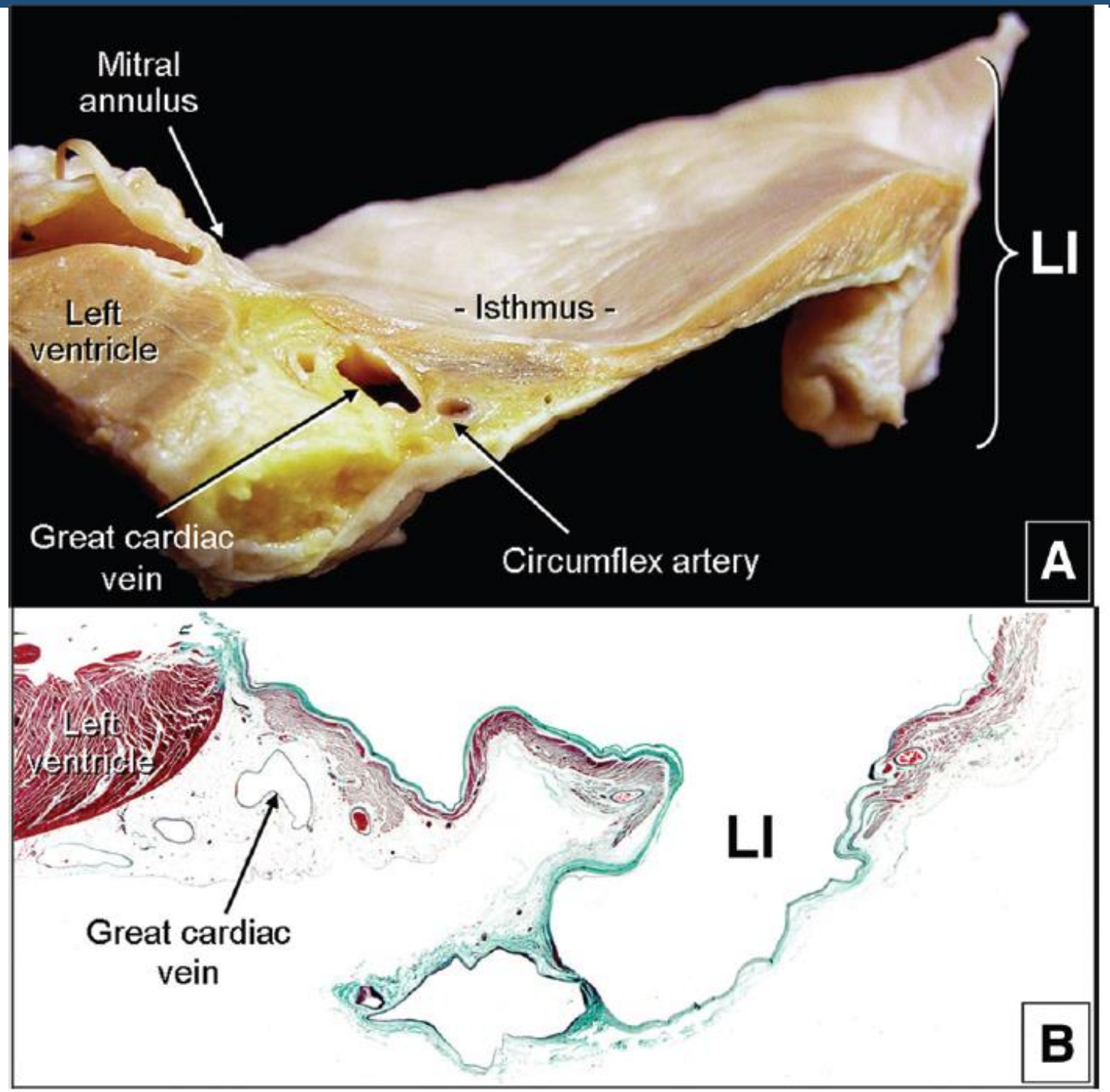
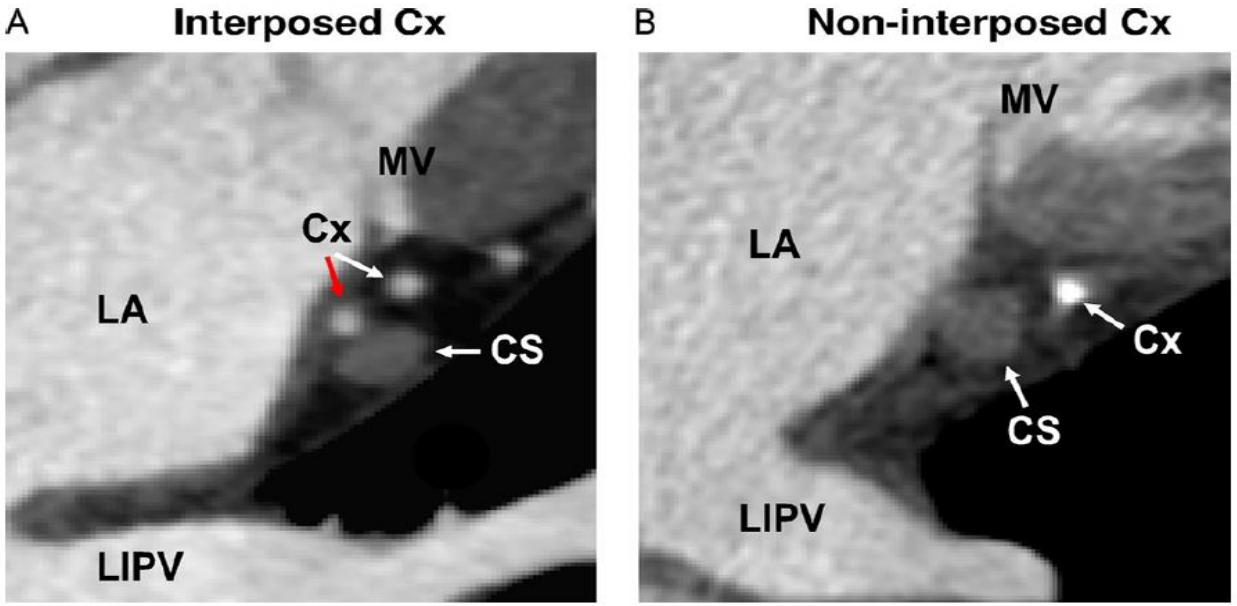

Mitral annulus
Left ventricle
- Isthmus -
LI
Great cardiac vein
Circumflex artery
A
Left ventricle
LI
Great cardiac vein
B

**Table 3** Multivariate predictors of incomplete mitral isthmus block

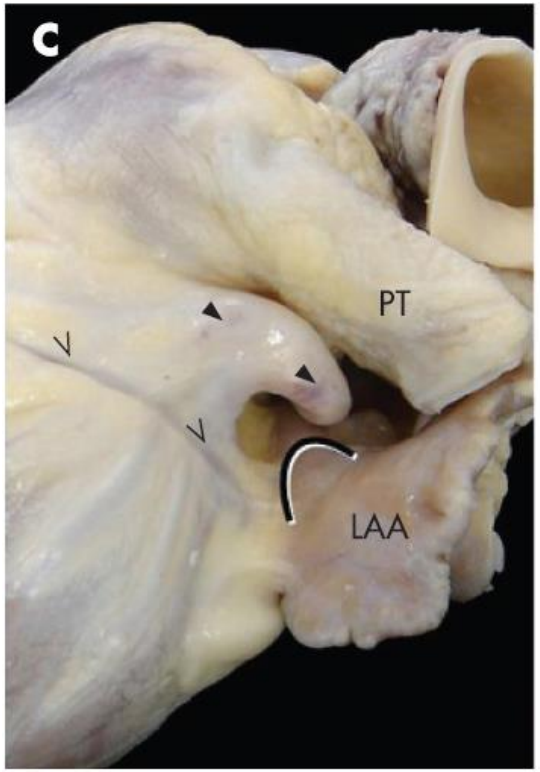
| Variables | Odd ratio (95% confidence interval) | *P* value |
|---|---|---|
| Left ventricular ejection fraction | 0.97 (0.92–1.03) | .34 |
| Depth | 0.98 (0.75–1.29) | .89 |
| Pouch morphology | 6.35 (0.43–93.9) | .18 |
| Interposed coronary artery | 4.90 (1.32–18.2) | .02 |

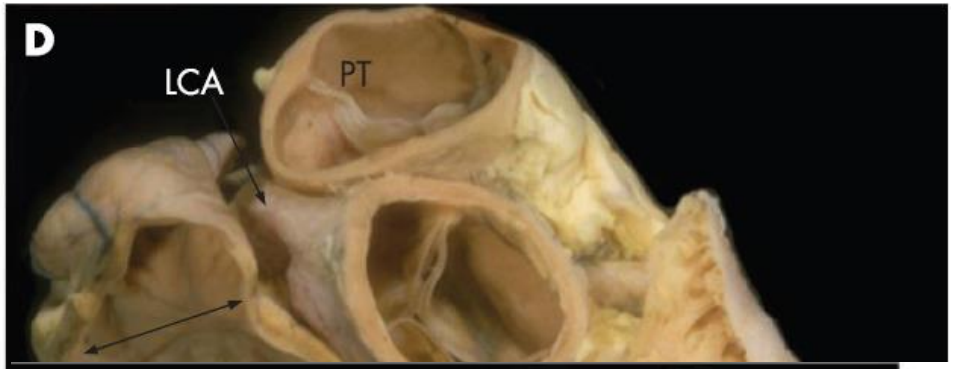


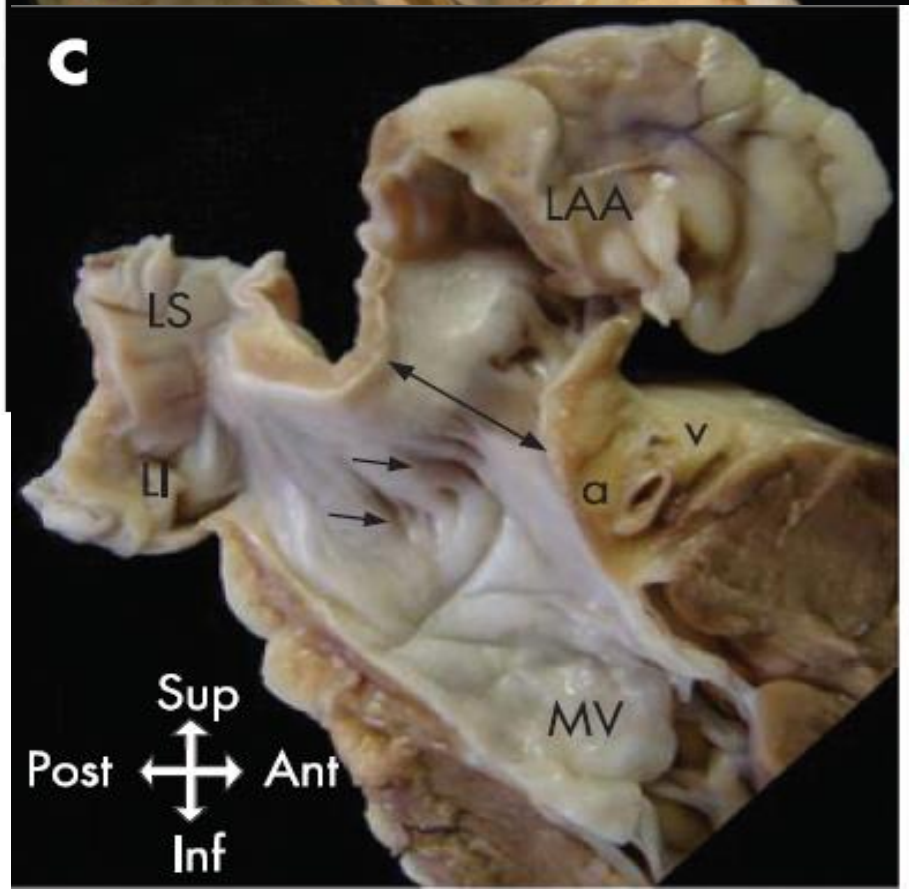

Conclusion:
Pre-procedural CT
May help to identify the patients with low probability of MI block

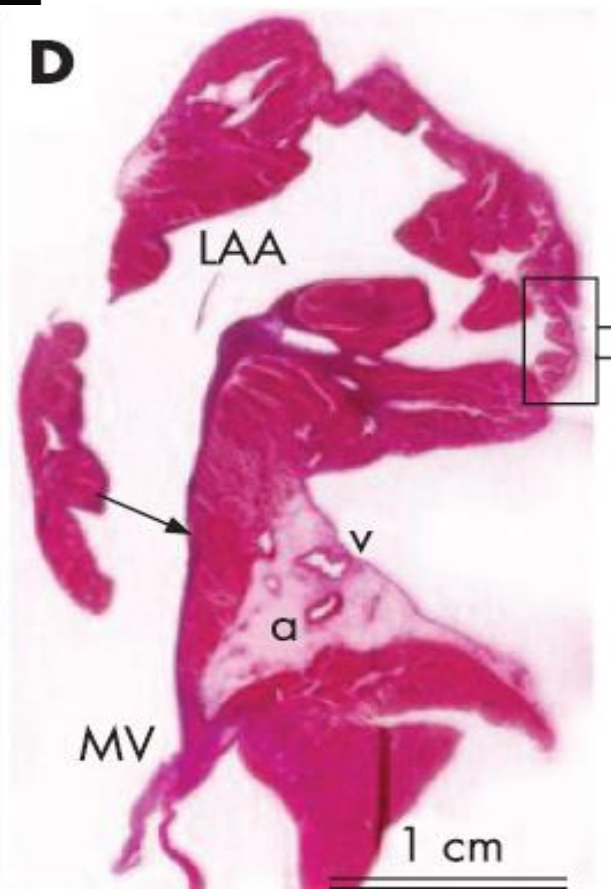
Yokokawa et al Heart Rhythm 2011

# Coronary artery and vein are close to LAA

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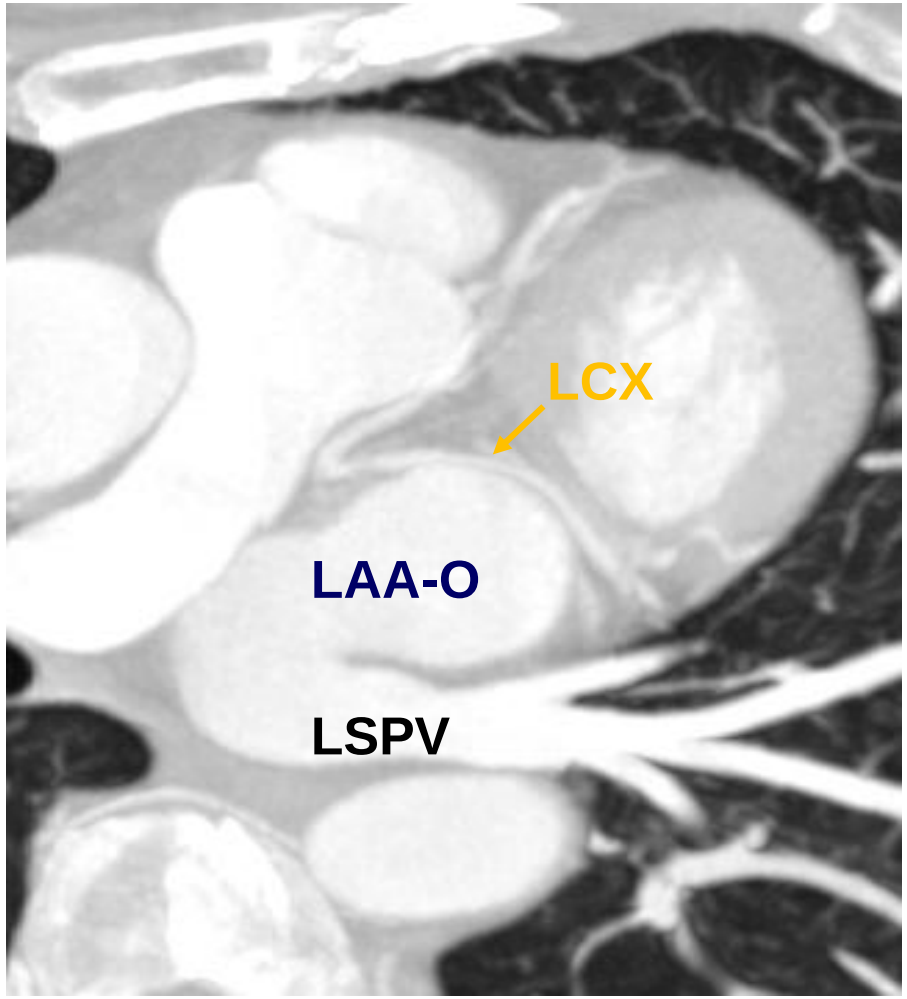
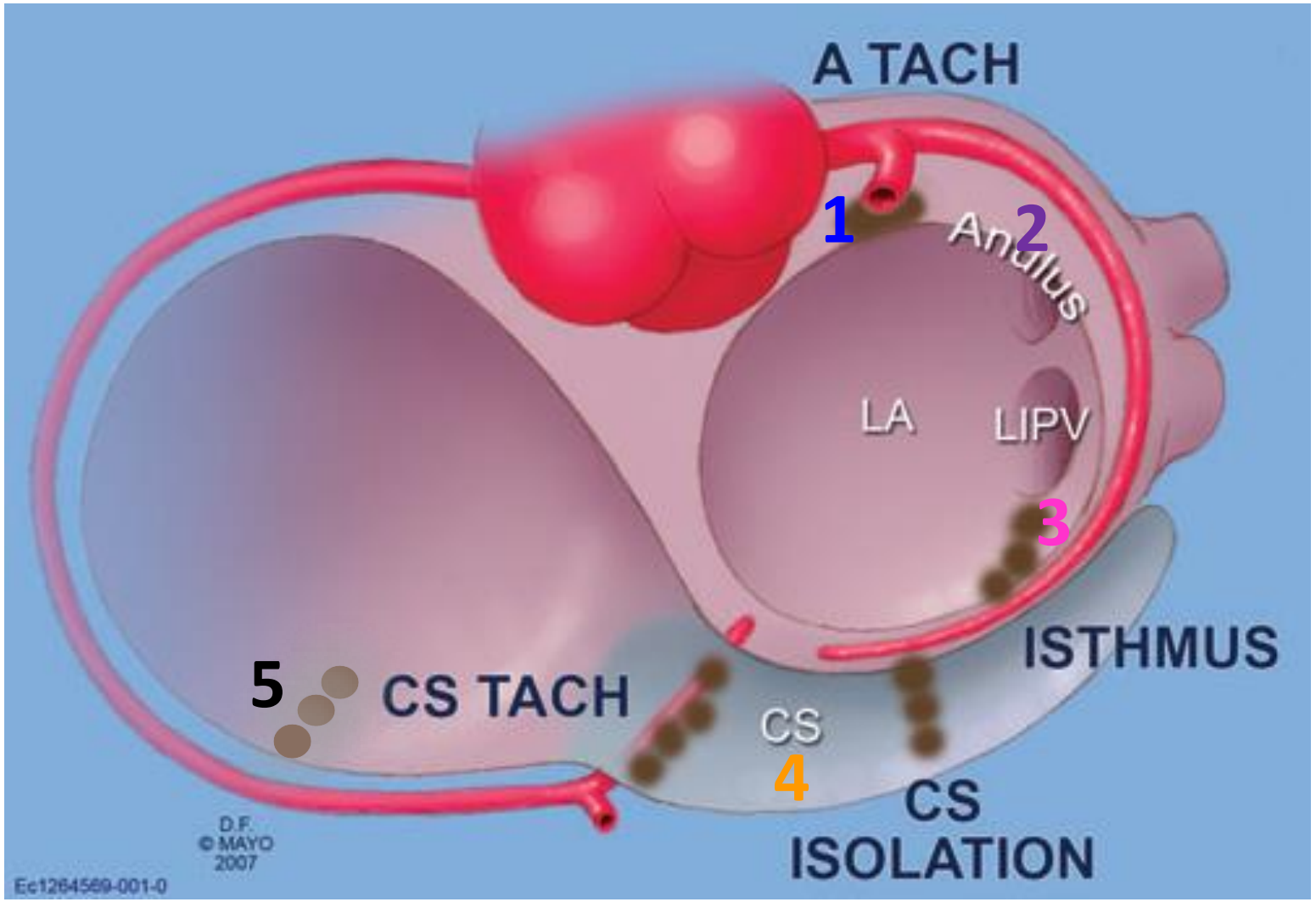
# Anatomic Proximity between LAA and Coronary Artery




- In 48% AF patients:
  the left circumflex artery was in direct contact with anterior part of LAA orifice
- Inferior type LAA was associated with shorter distance between LCX and LAA

Tsao and Chen JCE 2006

# Summary of potential coronary injury during AF ablation




1.Septal mitral annular tachycardia

2.LA appendage isolation

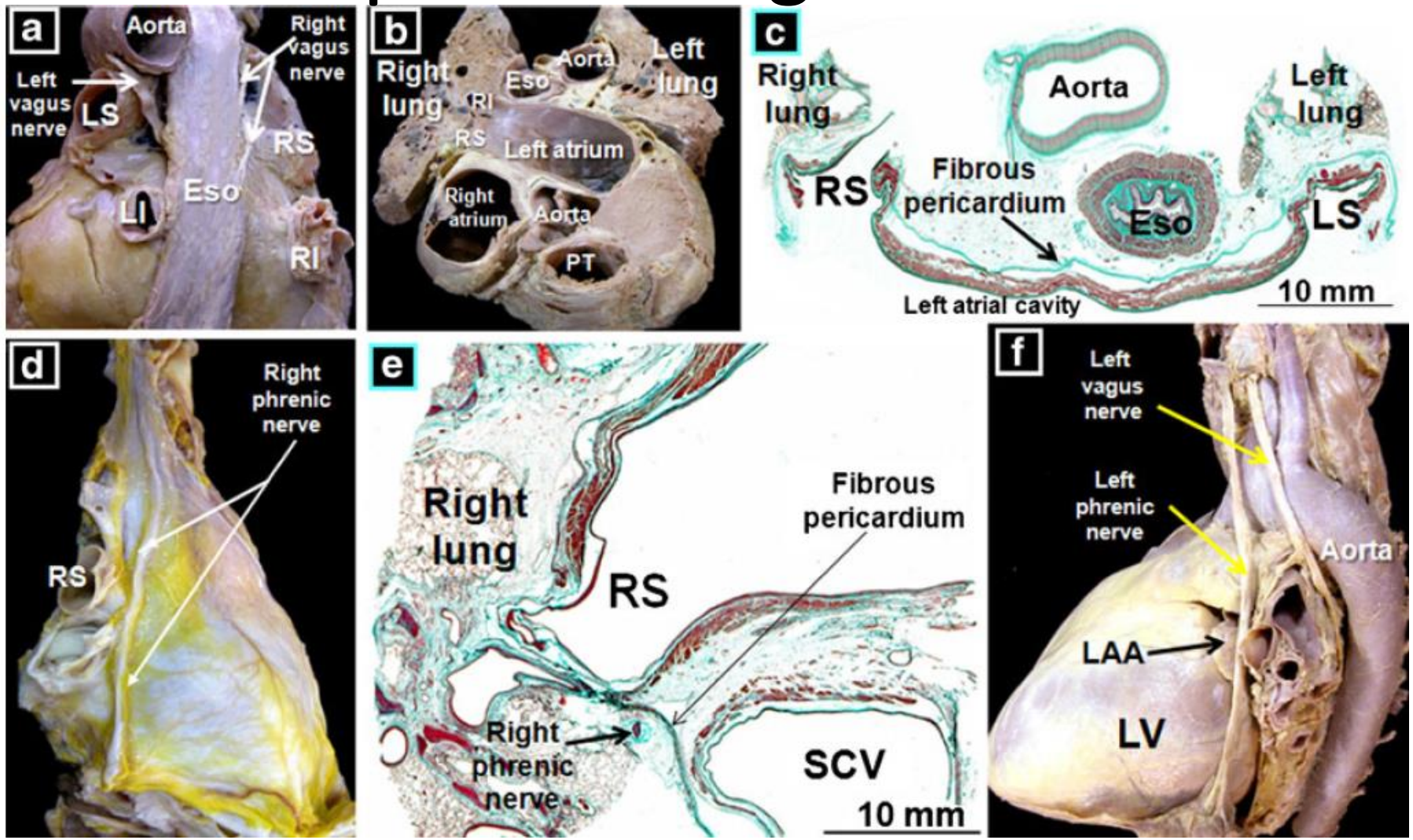
3.Lateral isthmus block

4.Coronary sinus isolation

5.RA low isthmus

modified from Macedo JCE 2010

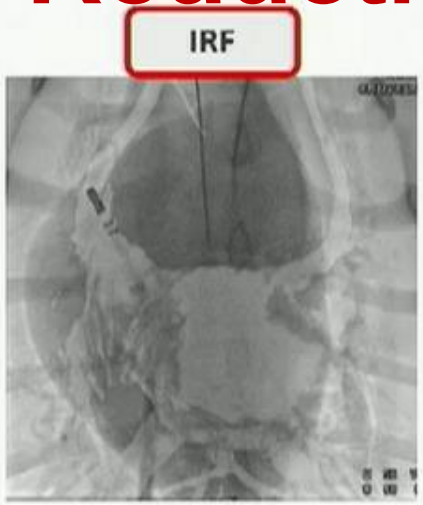
# Important neighborhood

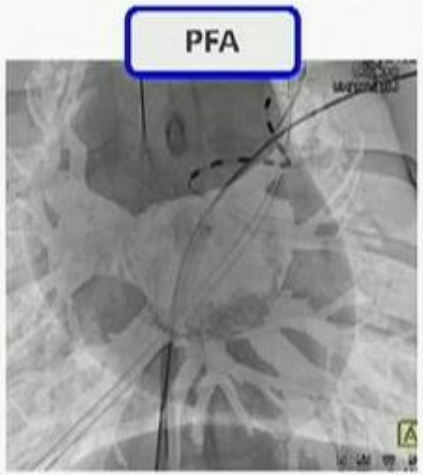


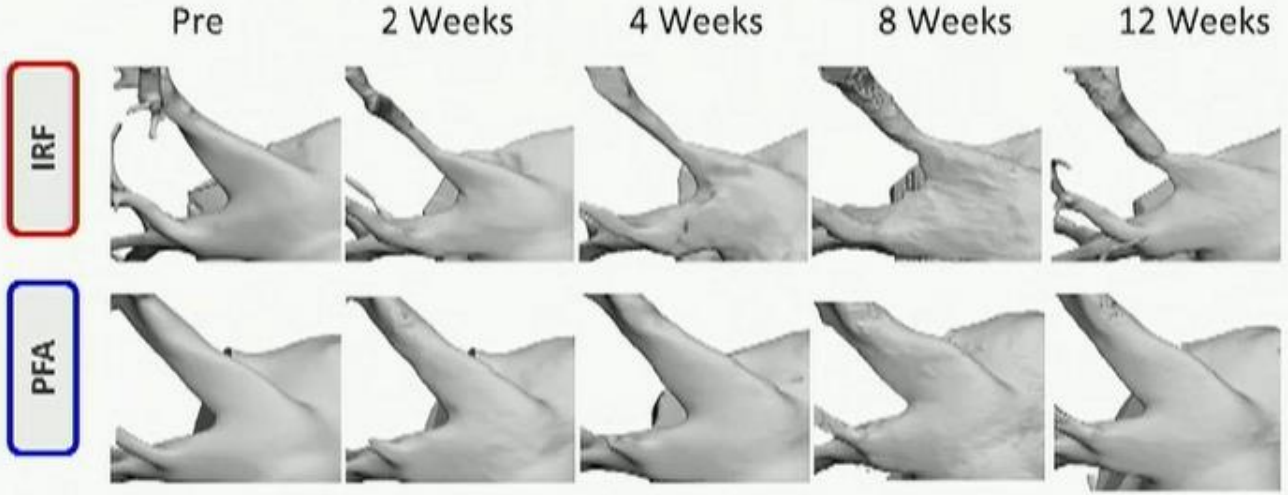

- **Proximity of esophagus to middle LA**
- **Right phrenic nerve is close to SVC and RSPV**
- **Left phrenic never is adjacent to LAA and lateral LV**

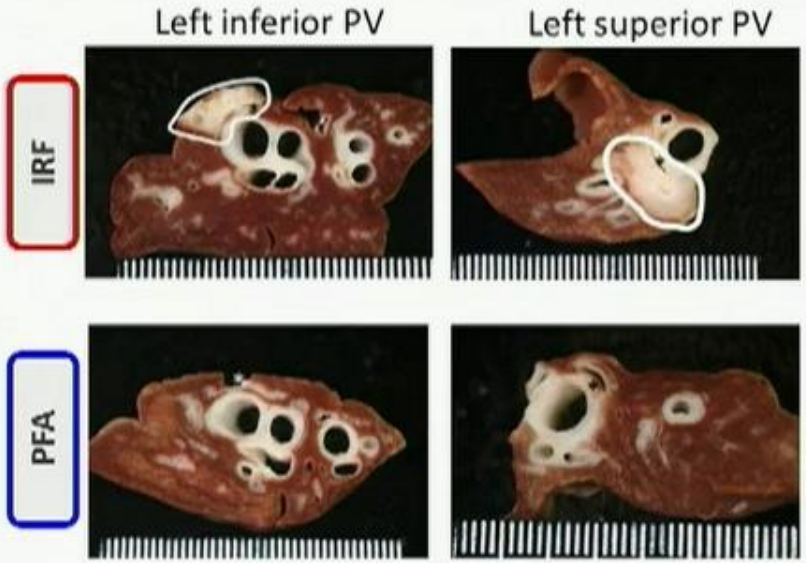
Sanchez-Quintana JCTR 2013

# Pulse Field Ablation
# ~Reduction of PV stenosis in a Canine Model~



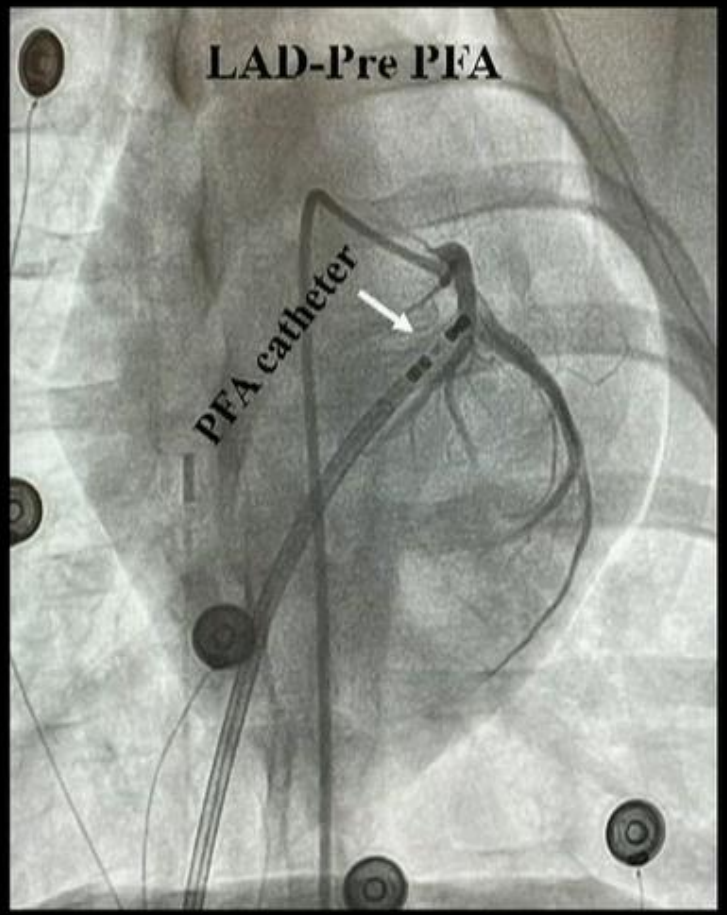



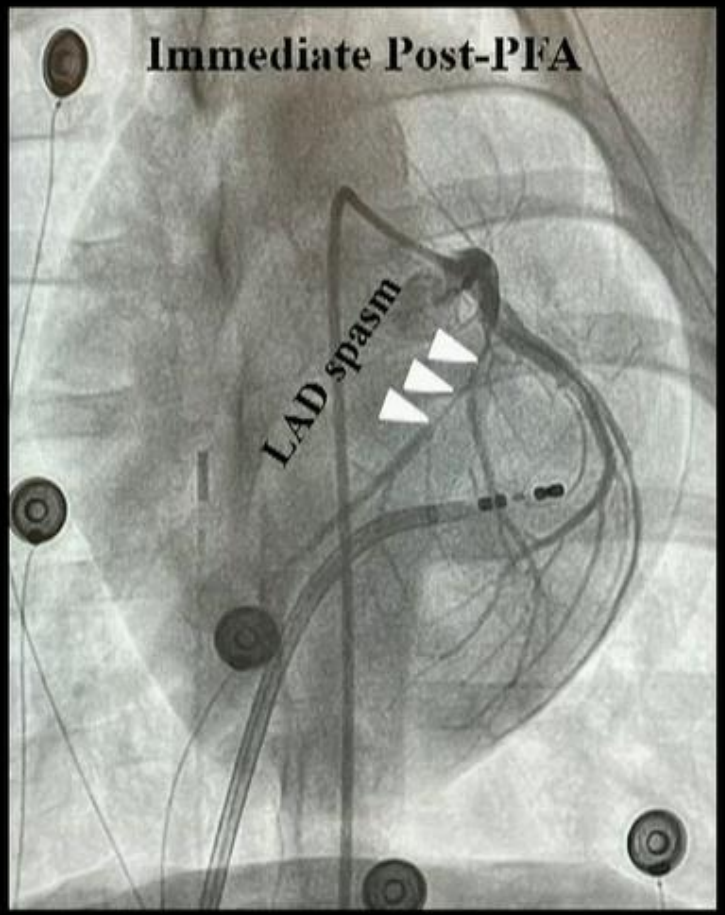



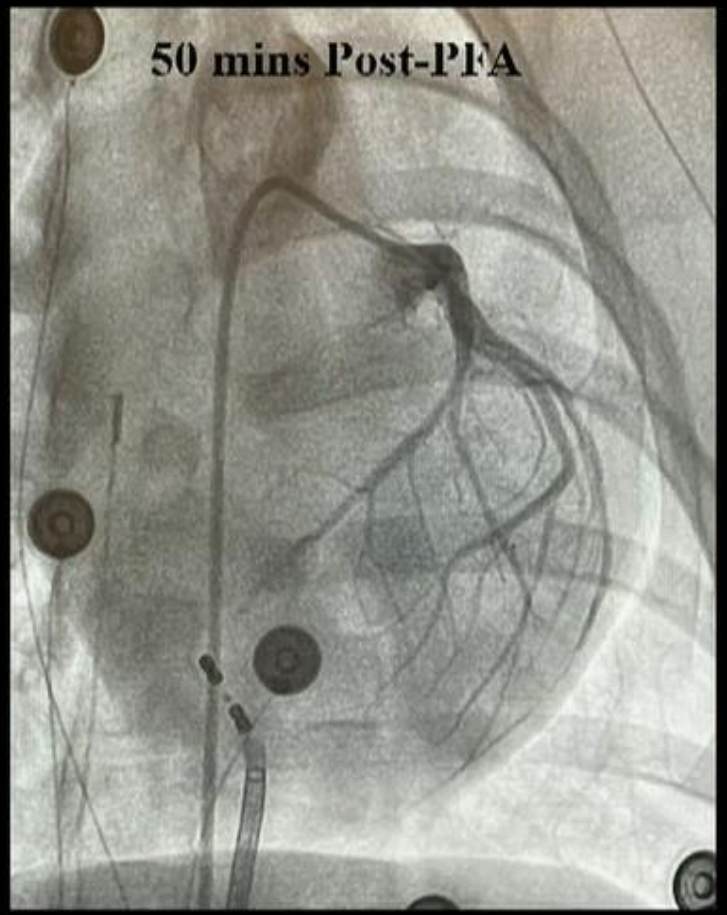

| | PFA | IRF |
|---|---|---|
| >20% PV stenosis | 0% | 21% |
| >70% PV stenosis | 0% | 11% |
| Lung injury | 0% | 94% |
| Vagal nerve injury | 0% | 88% |

- Howard, Brian, et al. "Reduction in pulmonary vein stenosis and collateral damage with pulsed field ablation compared with radiofrequency ablation in a canine model." *Circulation. Arrhythmia and Electrophysiology* 13.9 (2020): e008337

# Epicardial Ablation atop LAD Lesion below Epicardial Fat



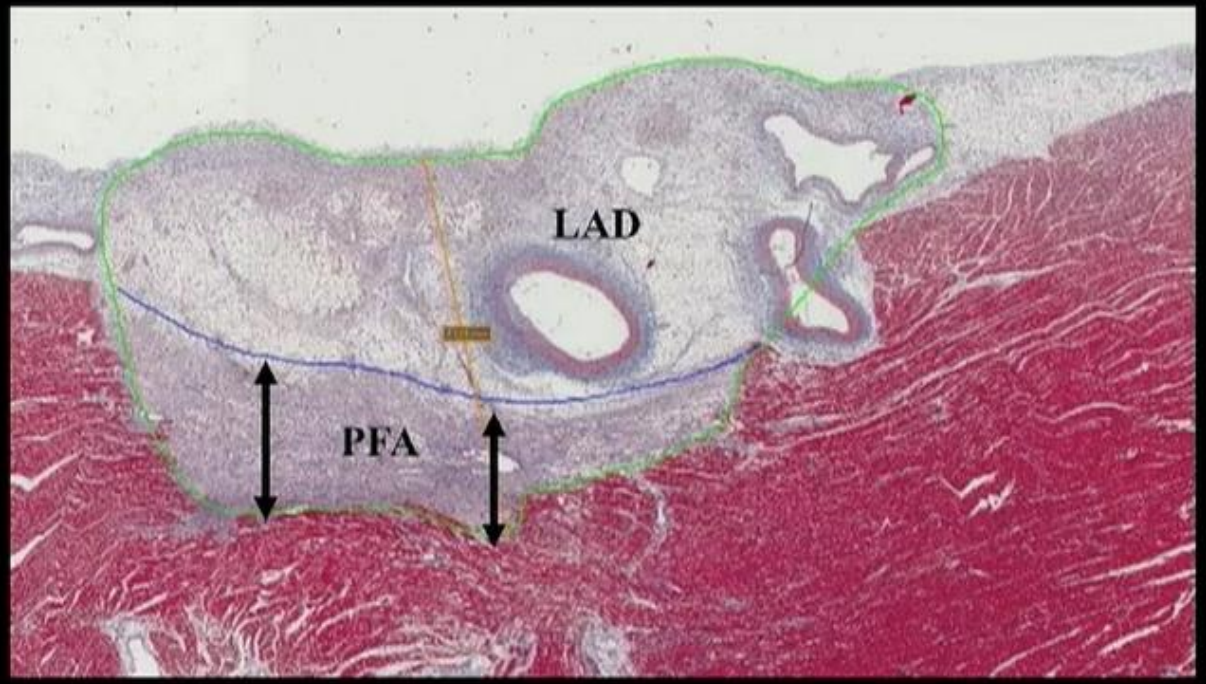



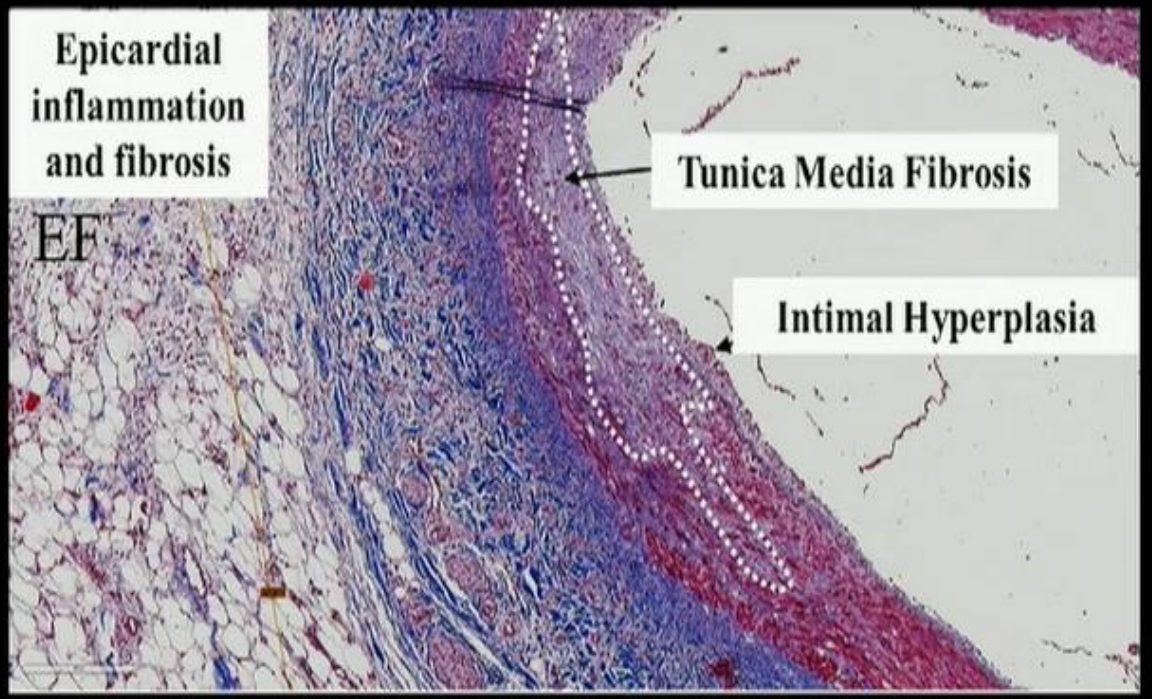

Jacob S. Koruth, HRS 2023

Understanding the Risk of Coronary Artery Spasm during Pulsed Field Ablation: Koruth, Kawamura, Reddy et al HRS 2022

# Epicardial ablation atop LAD
# Lesion below epicardial fat




# Zoomed view of LAD:
# Post PFA effects

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# Thank you for your attention