VT symposium 2018

Efficacy and safety of intracardiac echocardiography (ICE) in VT ablation

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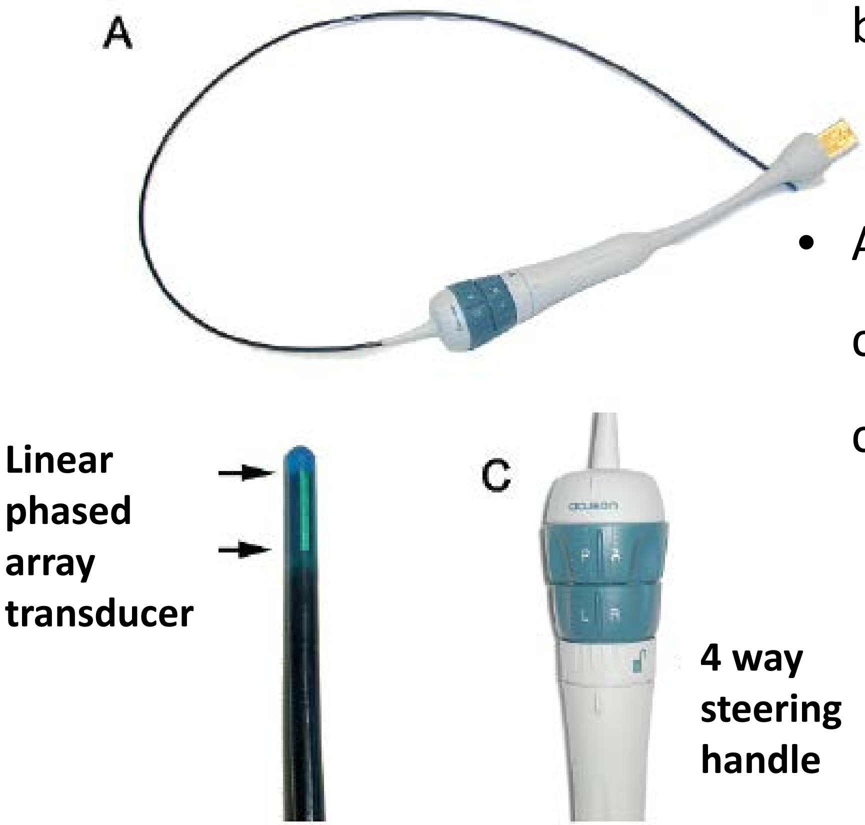
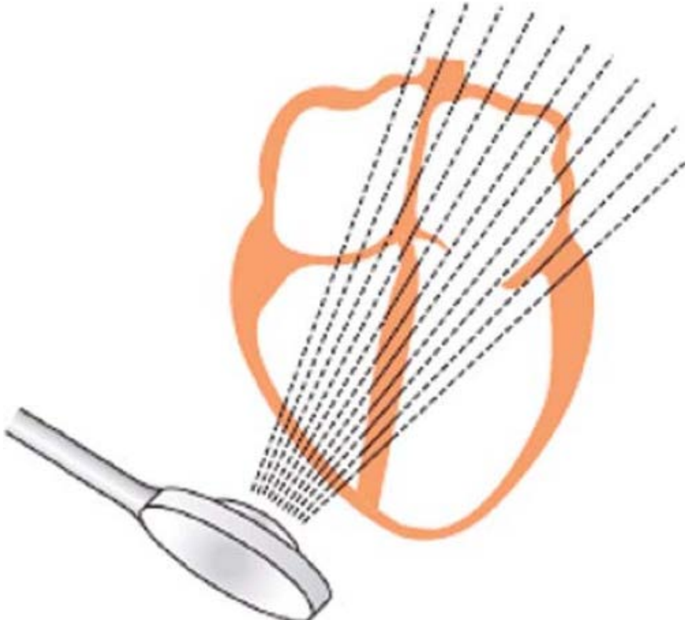
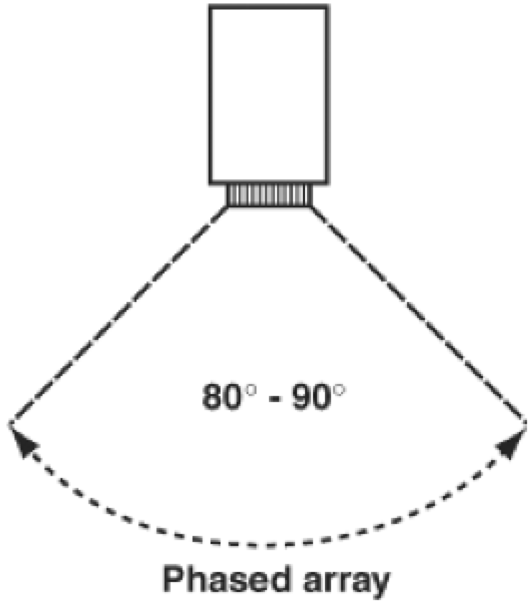
ICE CATHETER



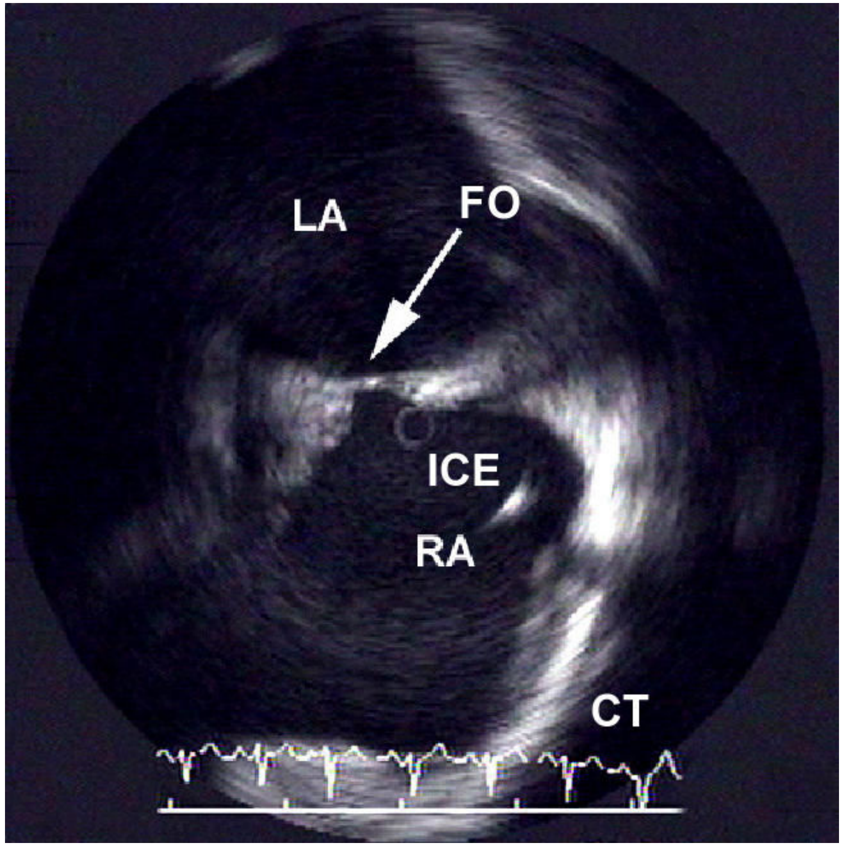
- Phased-array systems use a linear array of crystals parallel to the catheter body to produce a sector scan parallel to the long axis of the catheter.

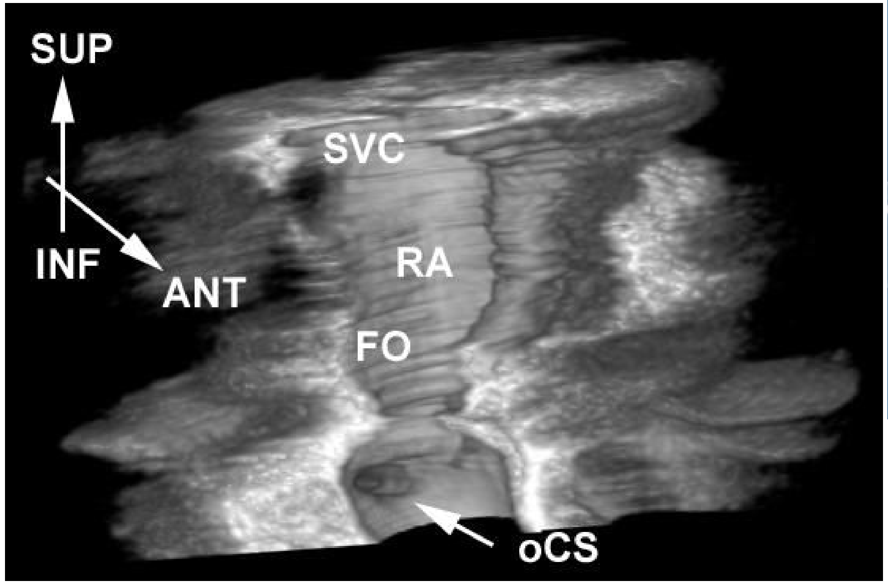
- A phased-array ultrasound-tipped catheter is preferable, especially in catheter-based ablation procedures because of sector imaging, flexibility in changing the frequency, and full Doppler capabilities.

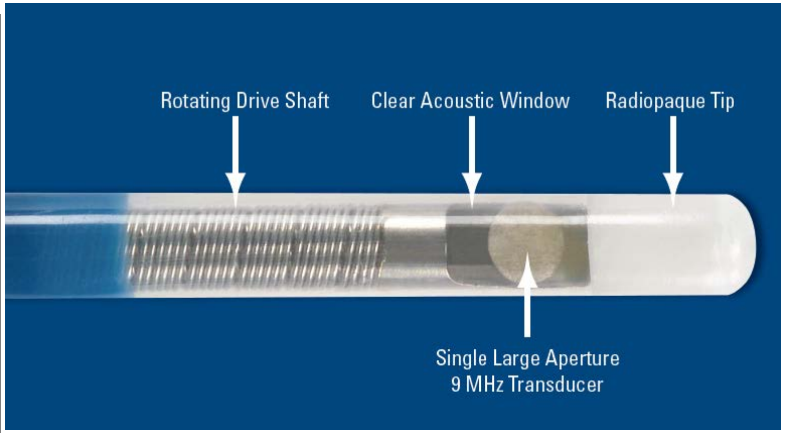


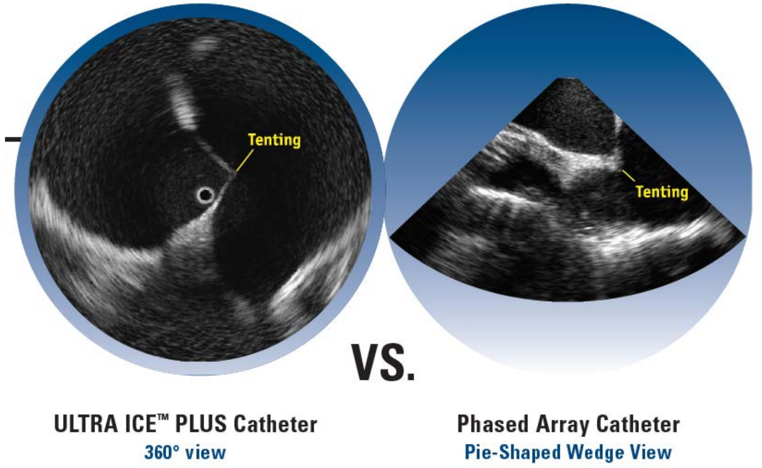


- Radial ICE: A crystal rotates providing cross-sectional images in a 360° radial plane. 3-D reconstruction of the anatomy can be obtained by puling the catheter within the heart.



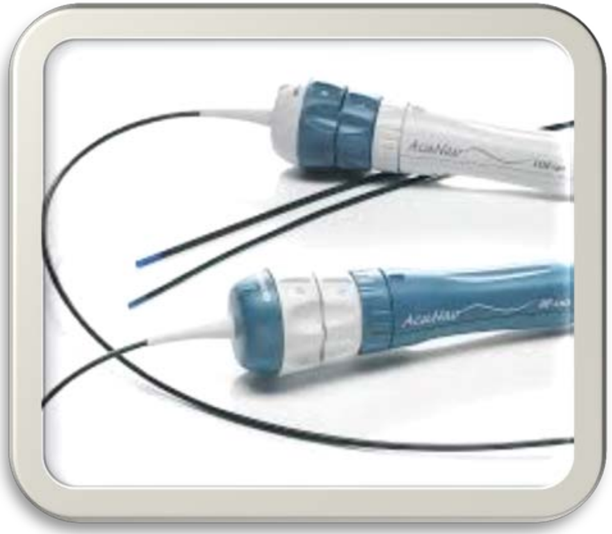


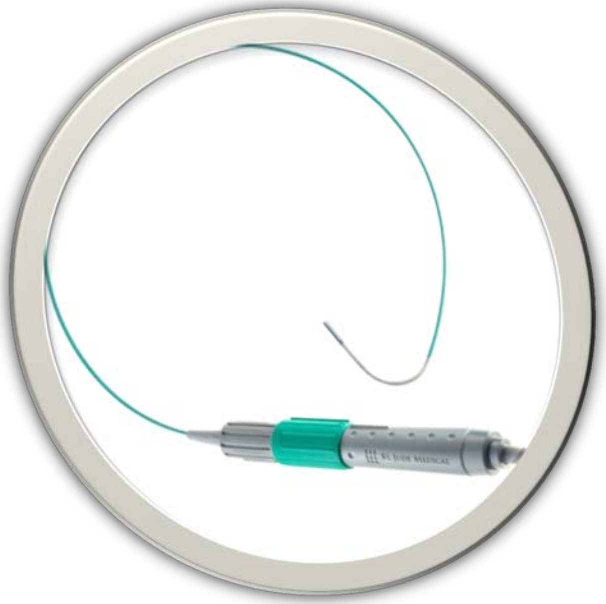




*Cardiovascular Ultrasound 20042:6

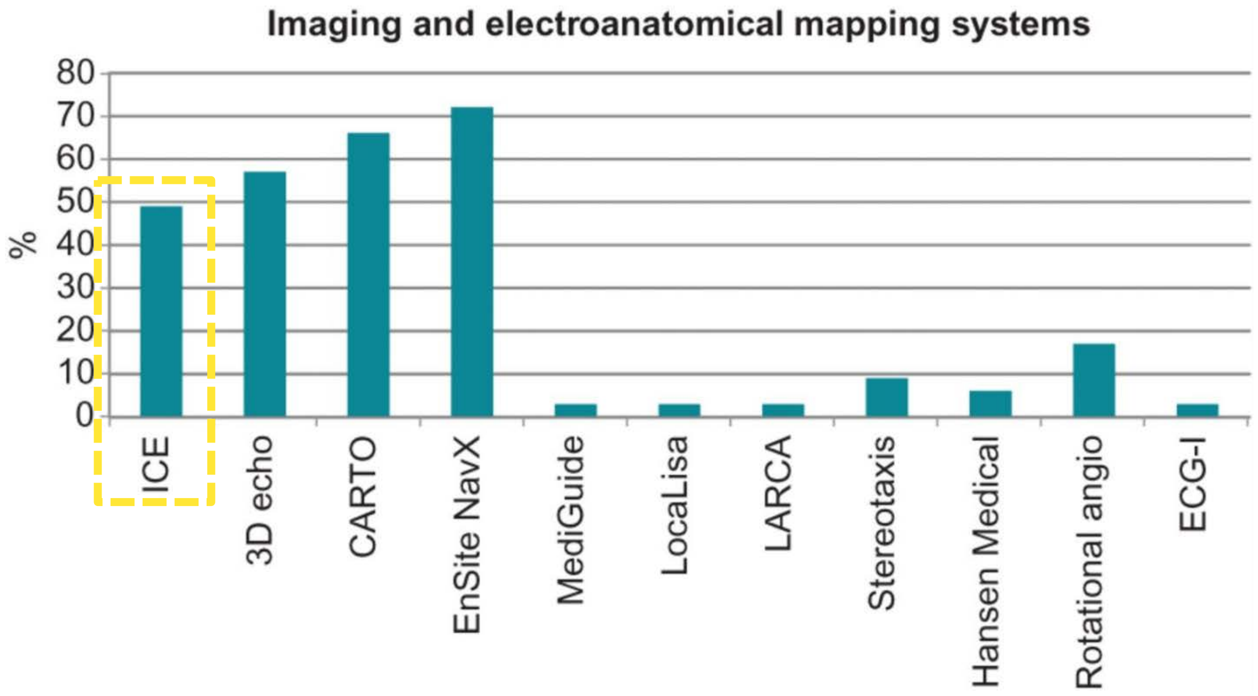
	ACUSON AcuNav™ ultrasound catheter	ViewFlex™ Xtra ICE Catheter
Fr/ length	8 or 10Fr/ 90cm	9Fr/ 90cm
Transducer	64-element phased array	64-element phased array
Penetration	15 cm	18 cm
Compatibility	GE or Siemens	Philips or Viewmate
Doppler capability	Yes	Yes
Other features	3D reconstruction (SOUNDSTAR™ eco 3D Ultrasound Catheter)	No need for sterilized cover; integrated connector, auto-lock steering





Imaging for guiding EP ablation procedure

- Imaging has become an integral part of EP procedure.
- The trend of image integration has been strengthened because anatomic structure play key roles in arrythmogenesis.



*JACC Cardiovasc Imaging. 2016 Jul;9(7):873-886. Europace. 2013 Sep;15(9):1333-6.

Experiences in SMC

- Between Nov 2017 and Aug 2018
- Total 136 ablation procedures with ICE; 33 cases in ablation for ventricular arrhythmia

Types	n (%)
VT or VPC - RVOT - LVOT - Other ventricular chambers	33 (24.3%) 14 4 15
AF/AFL	103 (75.7%)

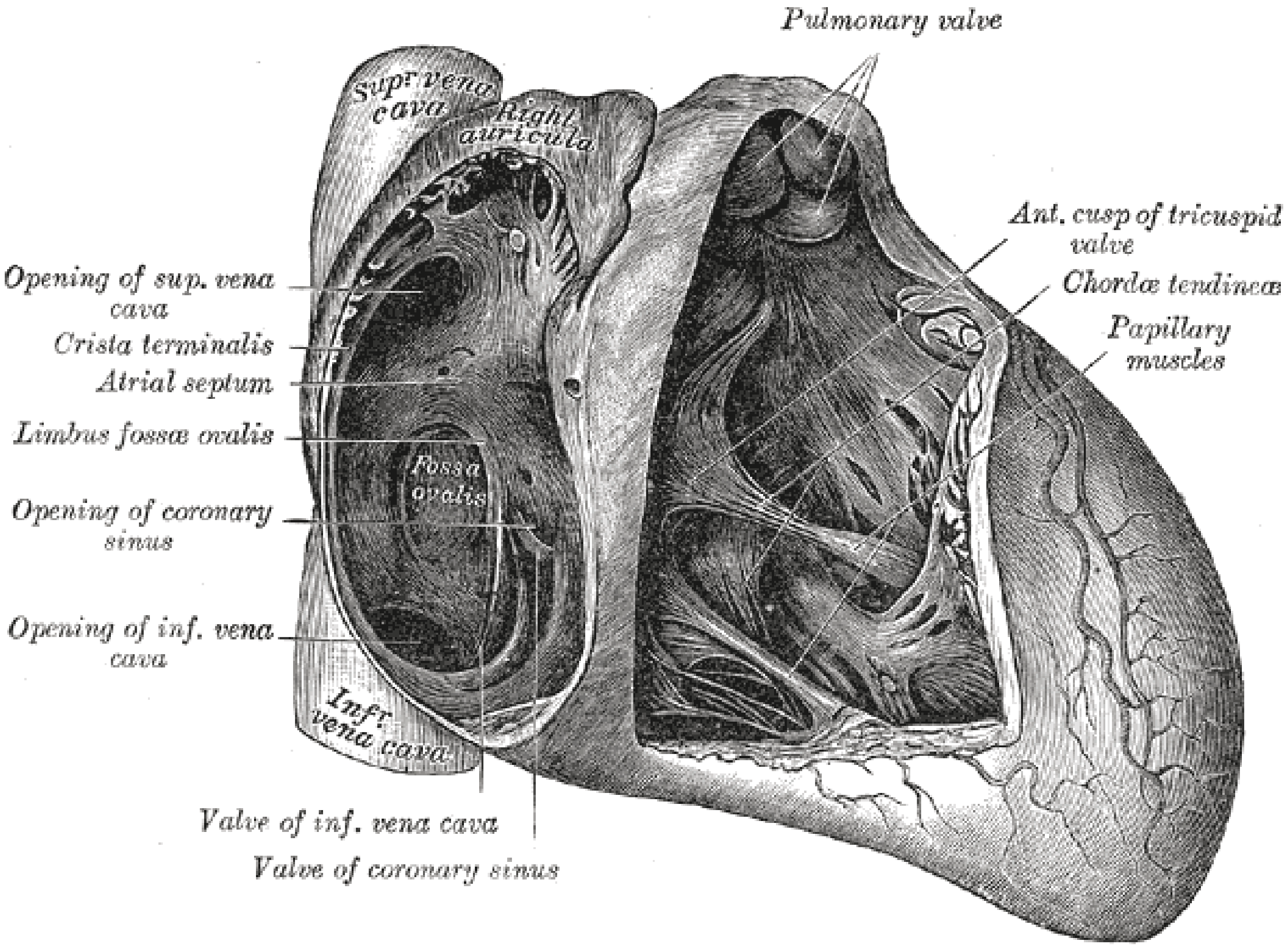
Role of ICE during VT ablation

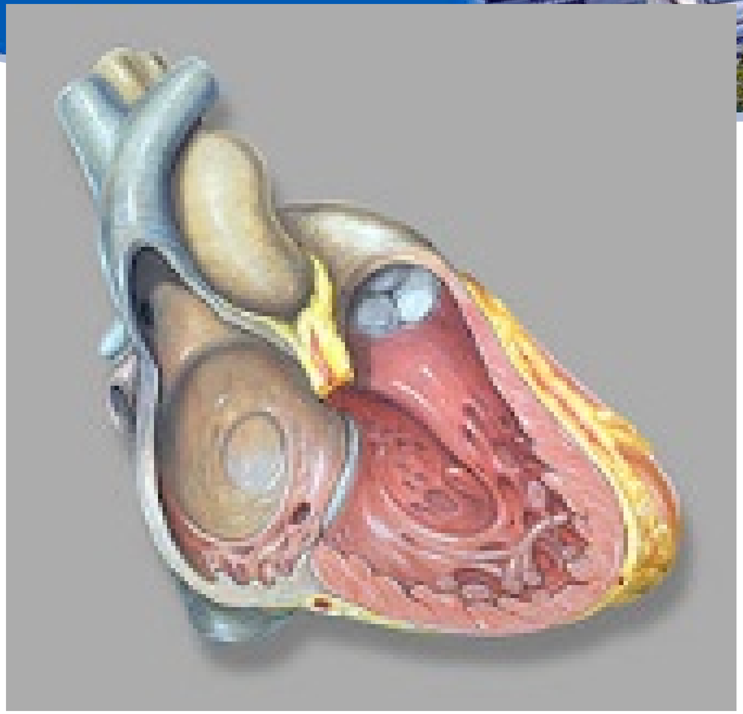
Direct visualization of anatomy, catheter, and lesion formation

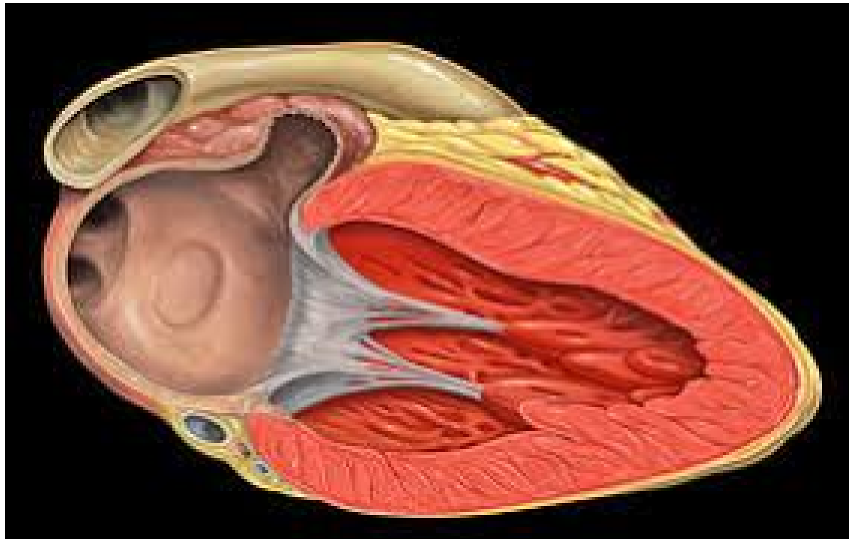
Identification of substrate

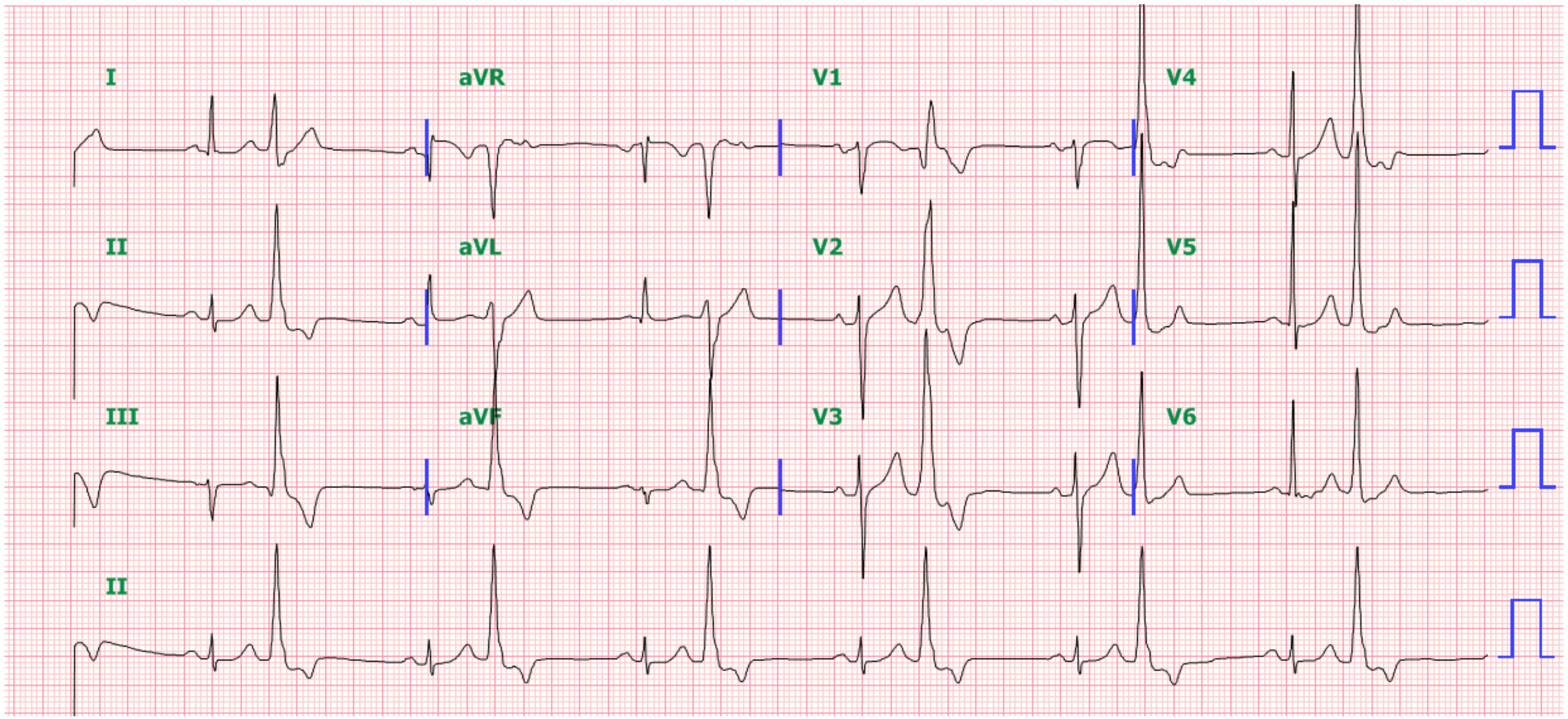
Continuous monitoring for complication

- ICE enables accurate anatomical confirmation of cardiac structures.



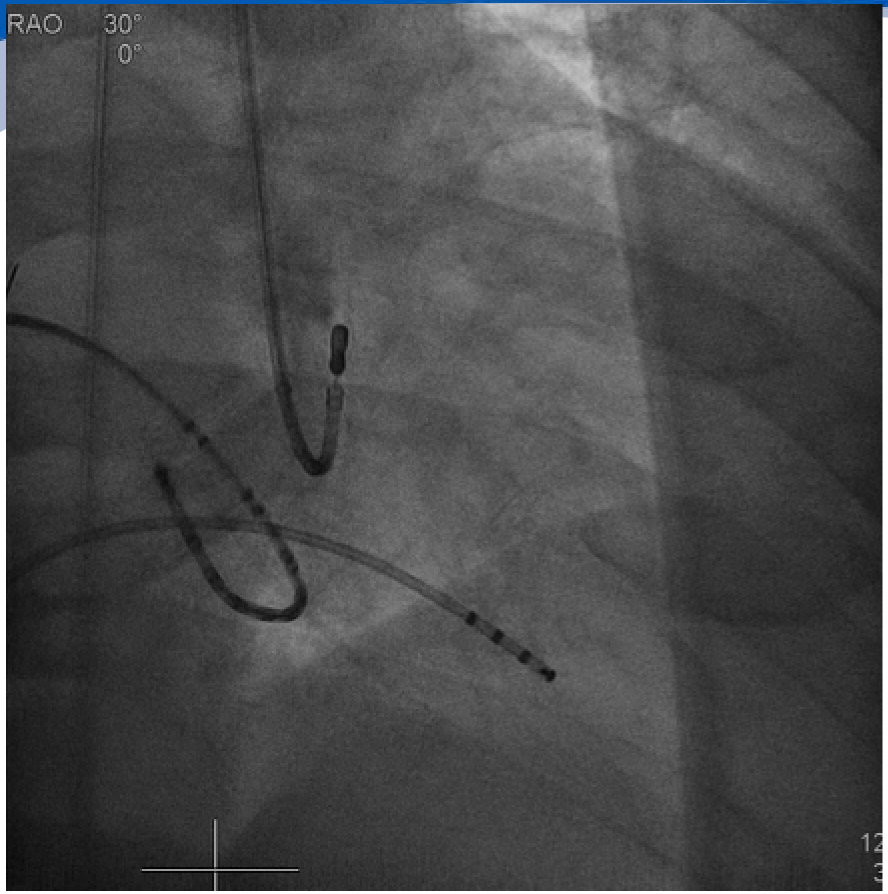


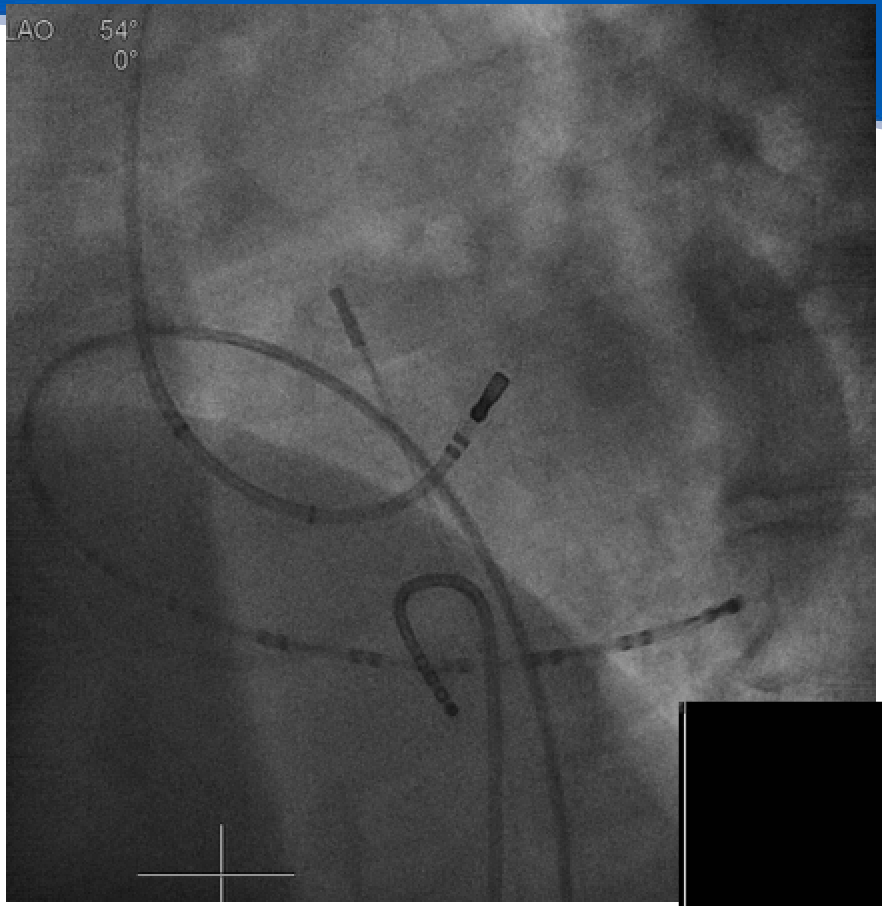




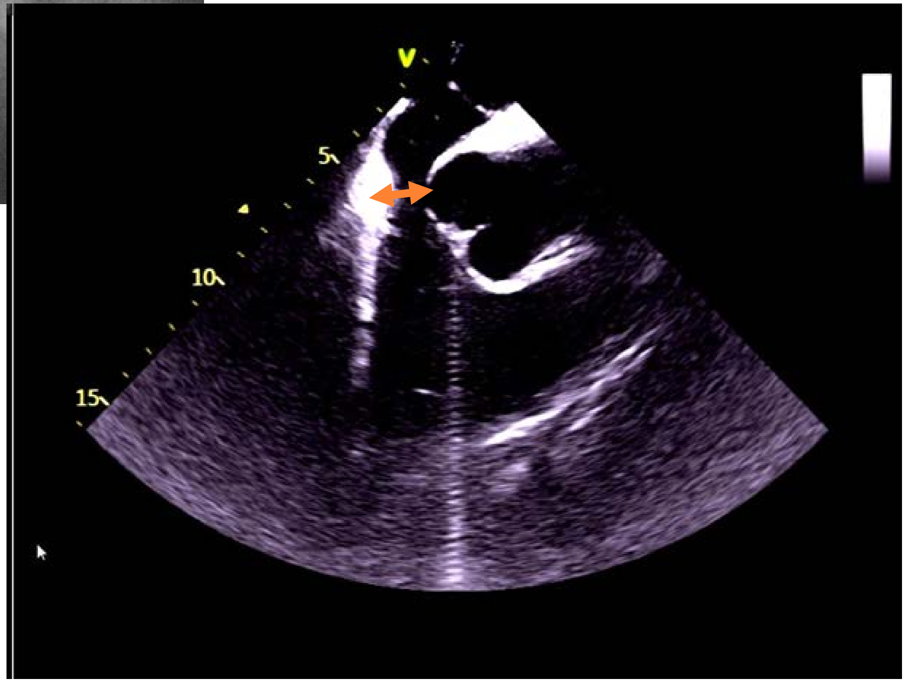
Real case:

63-year old male with frequent VPCs and VT; known aortic root dilatation and thoracic aortic aneurysm

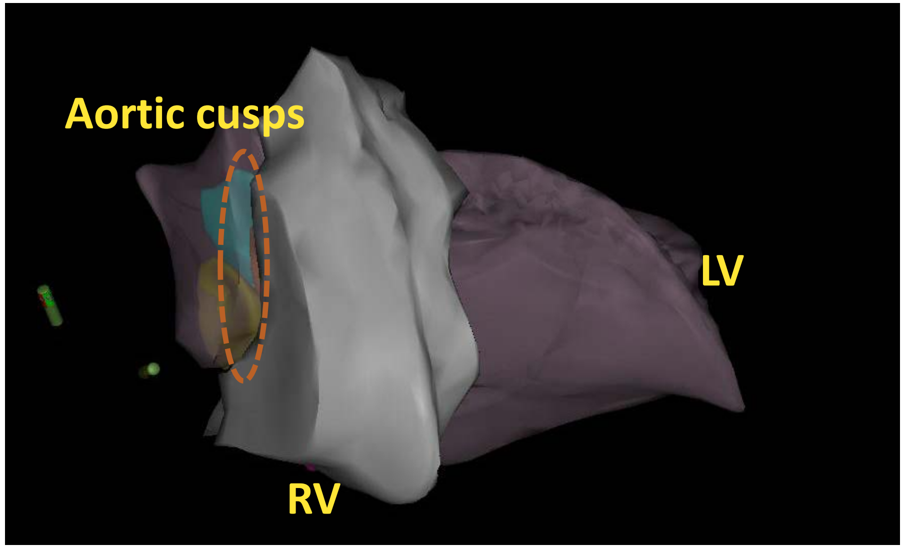




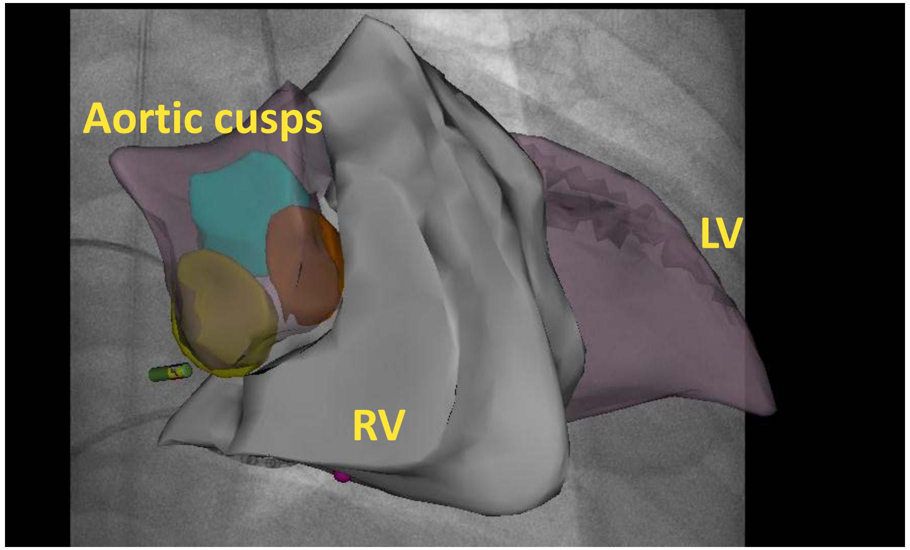
ICE image



Where is the ablation site?

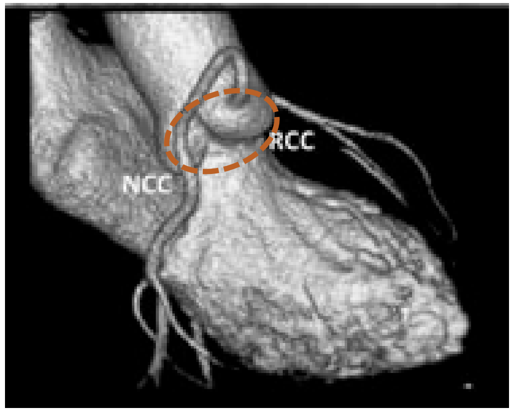


AP view

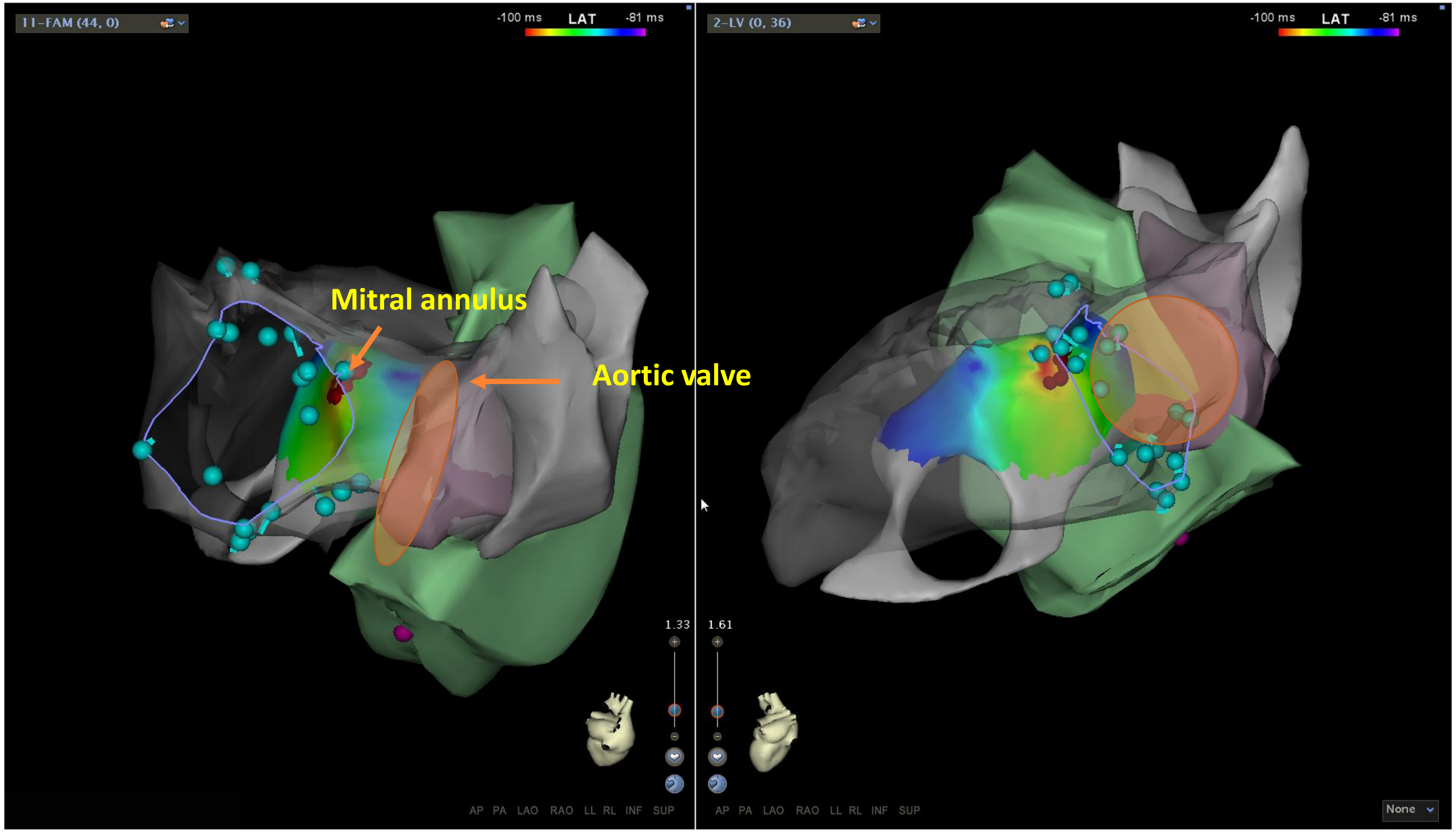


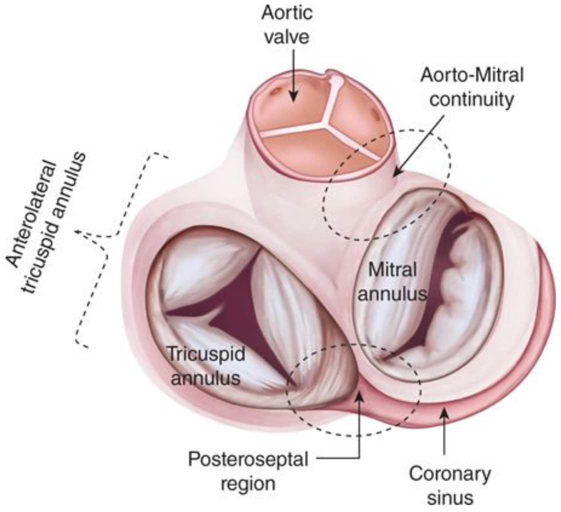
RAO view

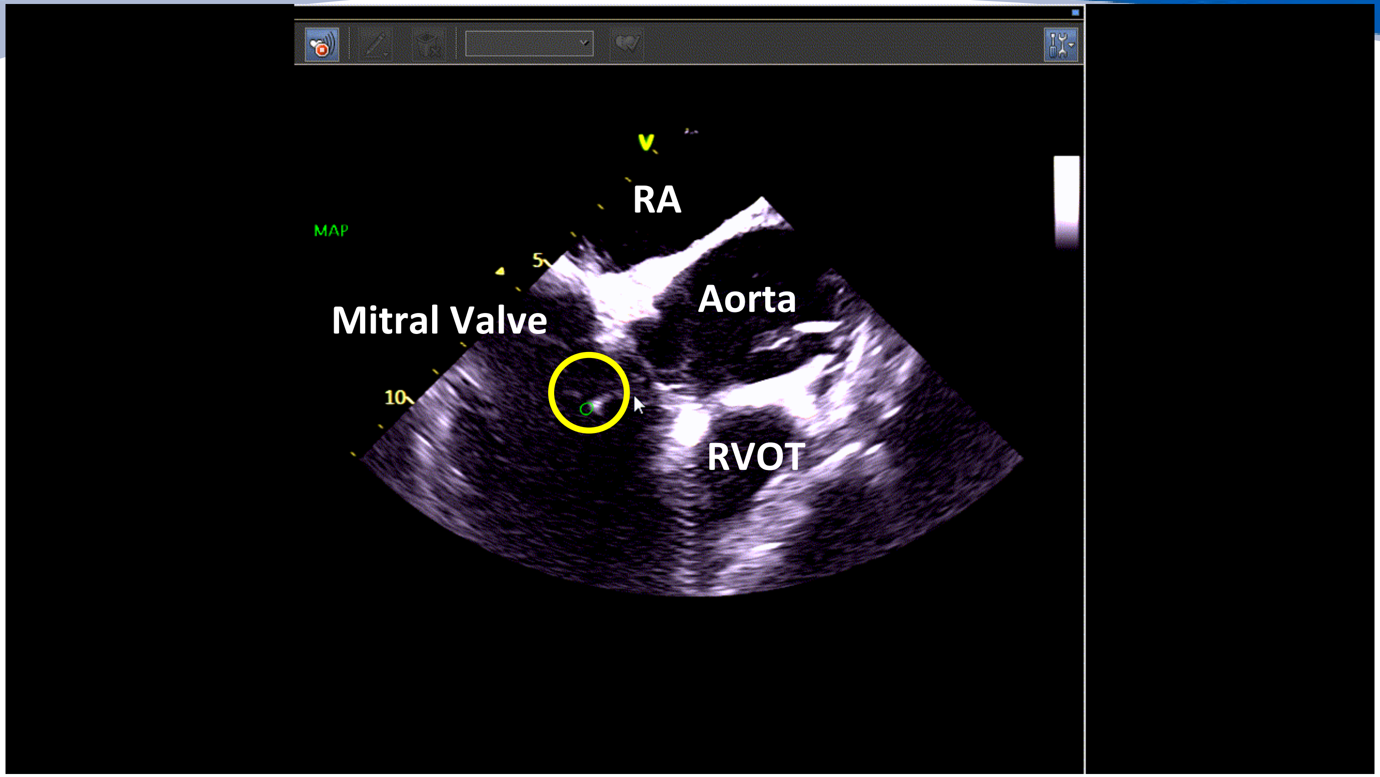
Vertically orientated aortic valve and sinus of Valsalva in patients with thoracic aorta aneurysm



Usual orientation (RAO)


11-FAM (44, 0)
-100 ms
LAT
-81 ms
Mitral annulus
Aortic valve
1.33
AP PA LAO RAO LL RL INF SUP
2-LV (0, 36)
-100 ms
LAT
-81 ms
1.61
AP PA LAO RAO LL RL INF SUP
None

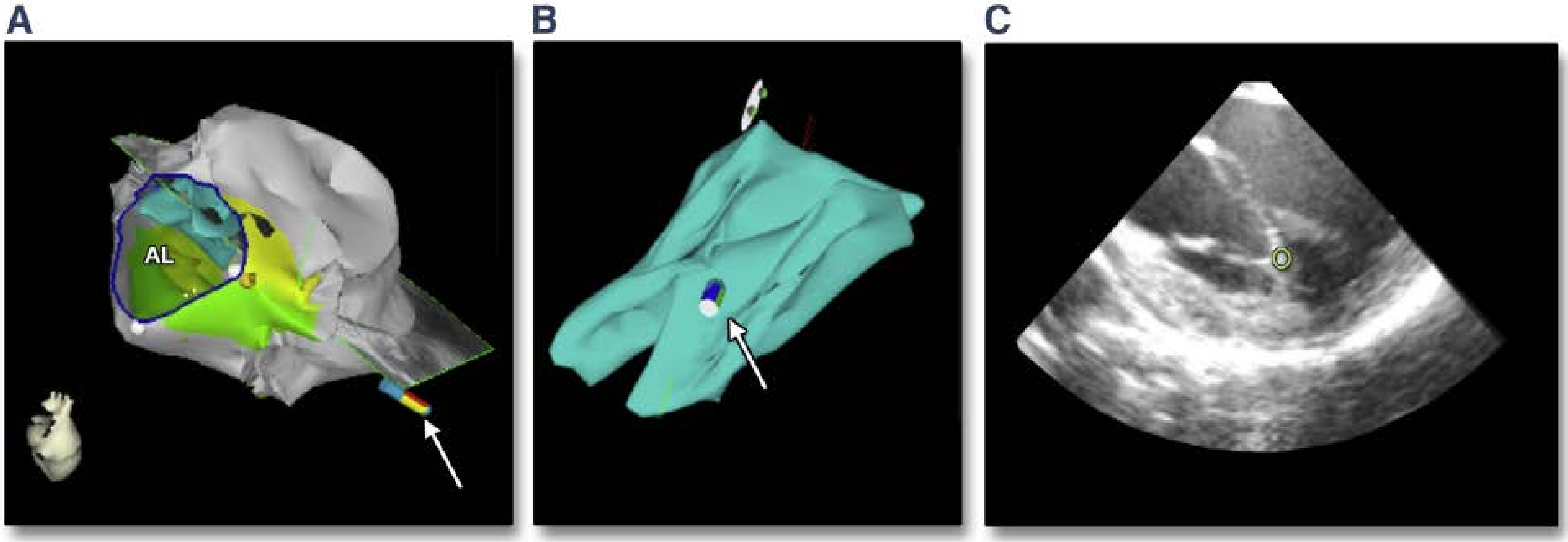

Aortic valve
Aorto-Mitral continuity
Anterolateral tricuspid annulus
Mitral annulus
Tricuspid annulus
Posteroseptal region
Coronary sinus



Ablation catheter tip on the AMC

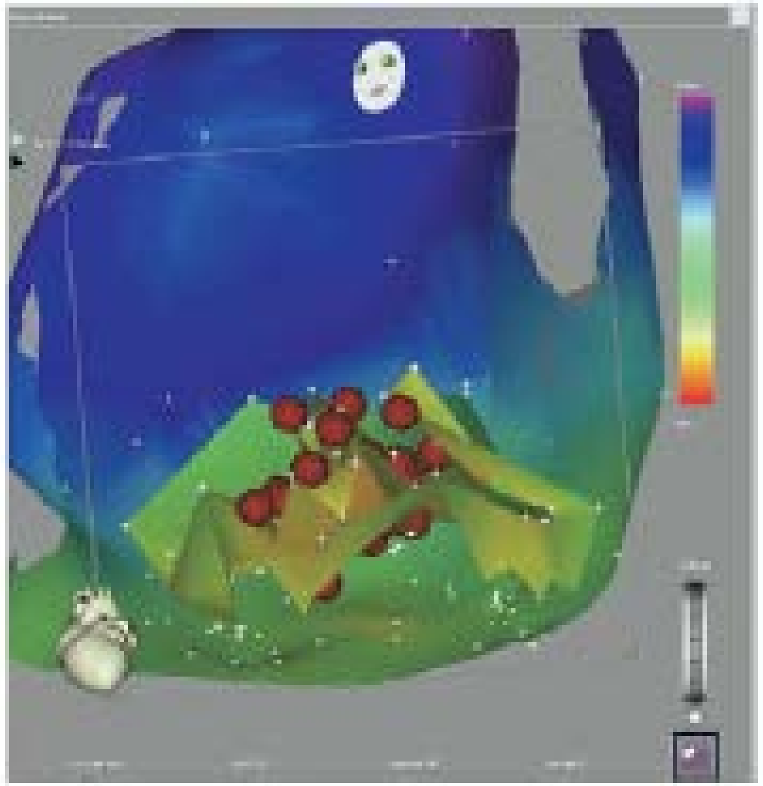
- The visualization of the catheter into the ultrasound image is of key importance to <u>target locations that are constantly moving</u>.
- The challenge is to map the PM to identify the origin of VT and to keep the catheter at a critical location d uring RF energy delivery.

- **Papillary muscle (PM) in ICE images**

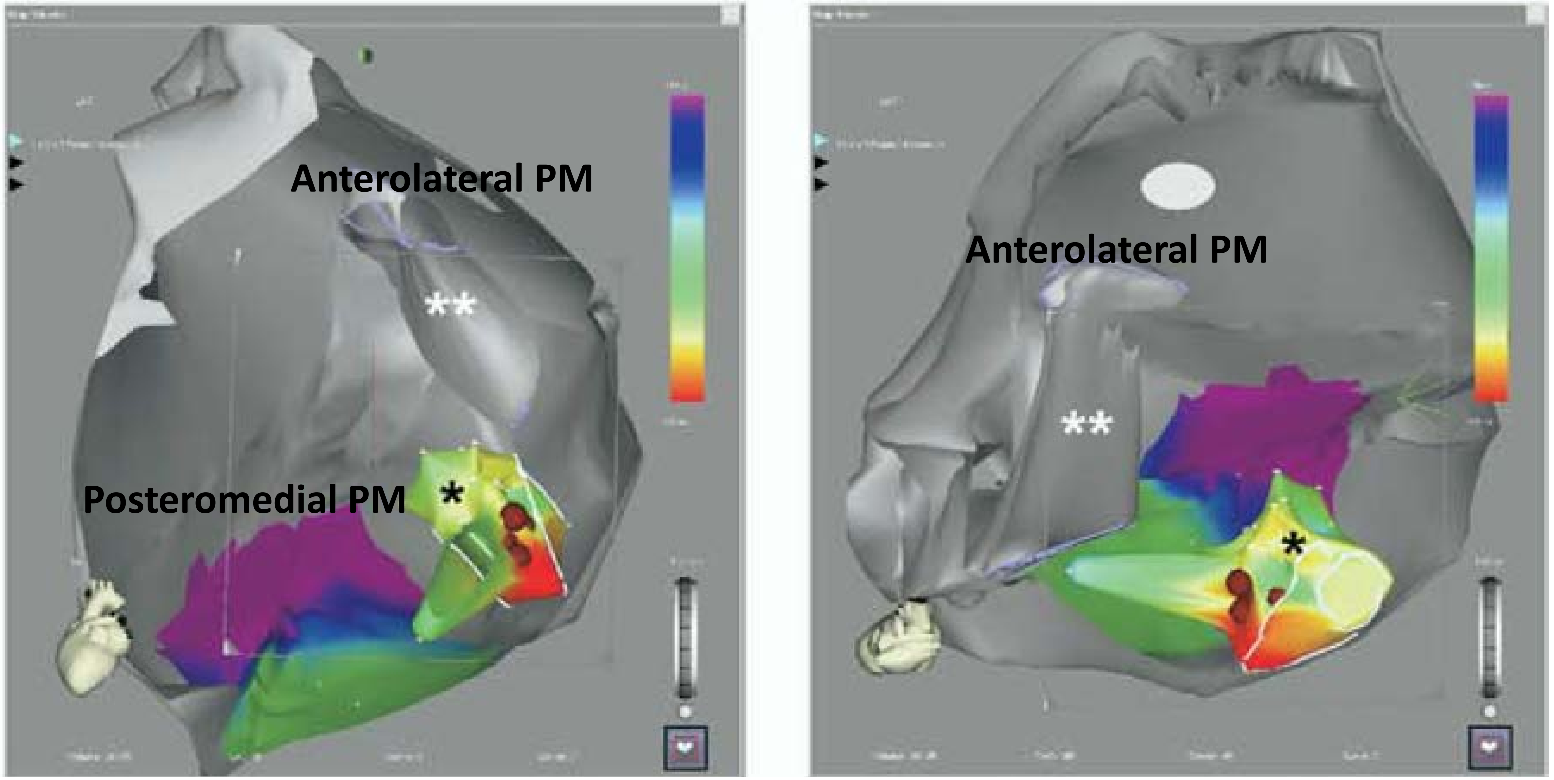


Anterolateral PM with 2 heads

*JACC Cardiovasc Imaging. 2016 Jul;9(7):873-886.

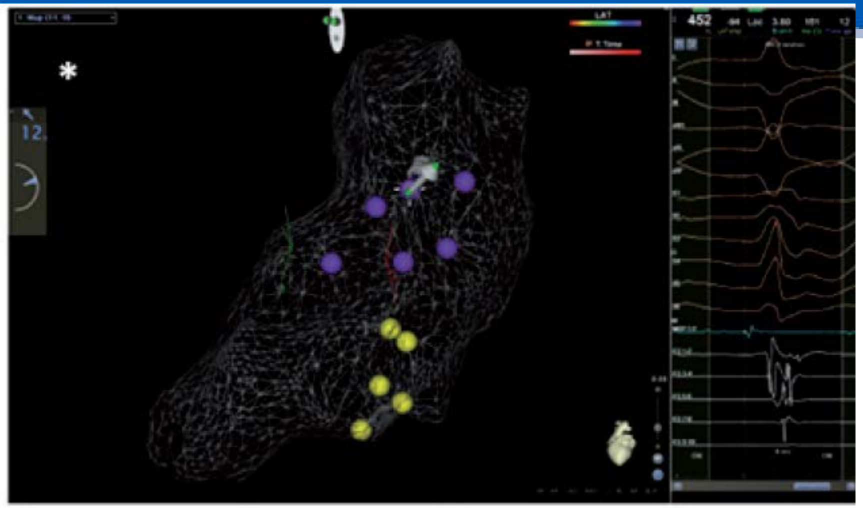


First ablation

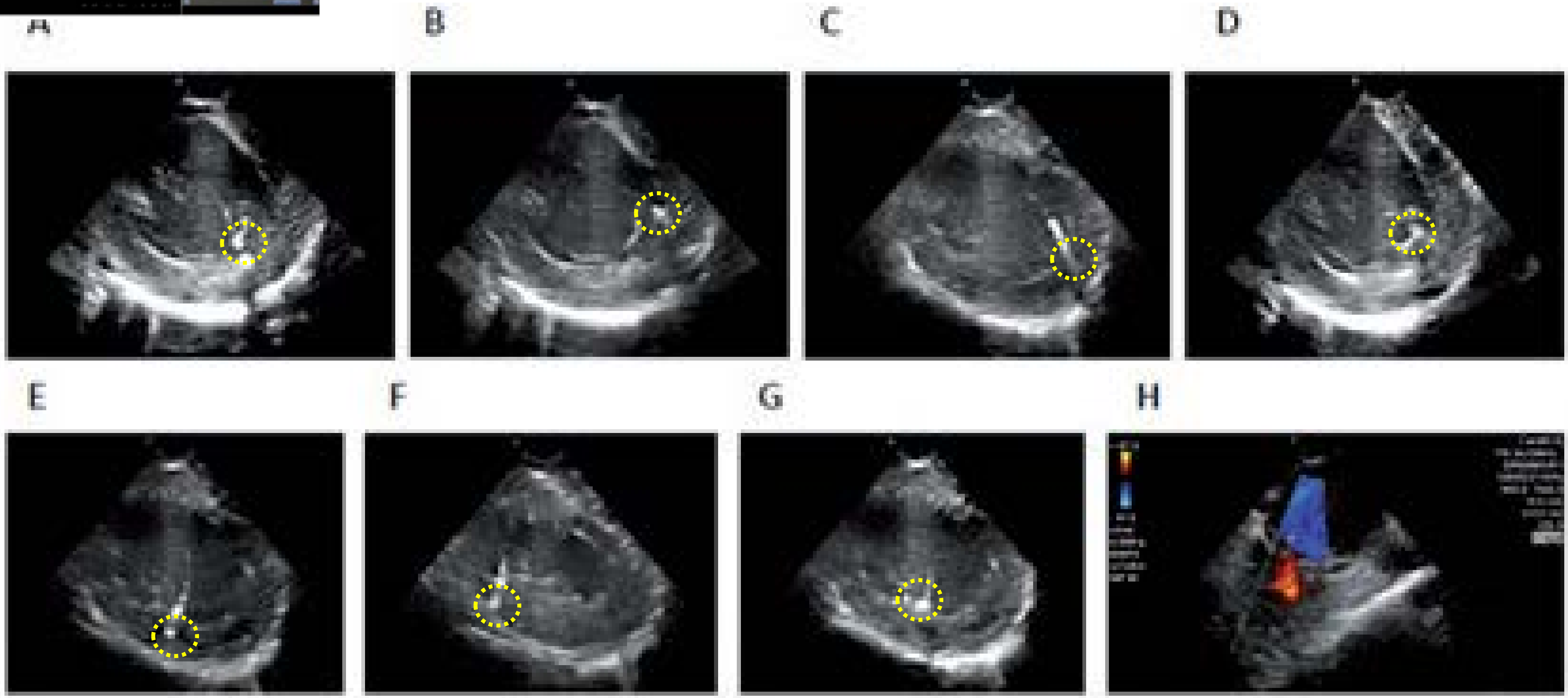


2nd ablation

*Heart Rhythm. 2009 Mar;6(3):389-92.

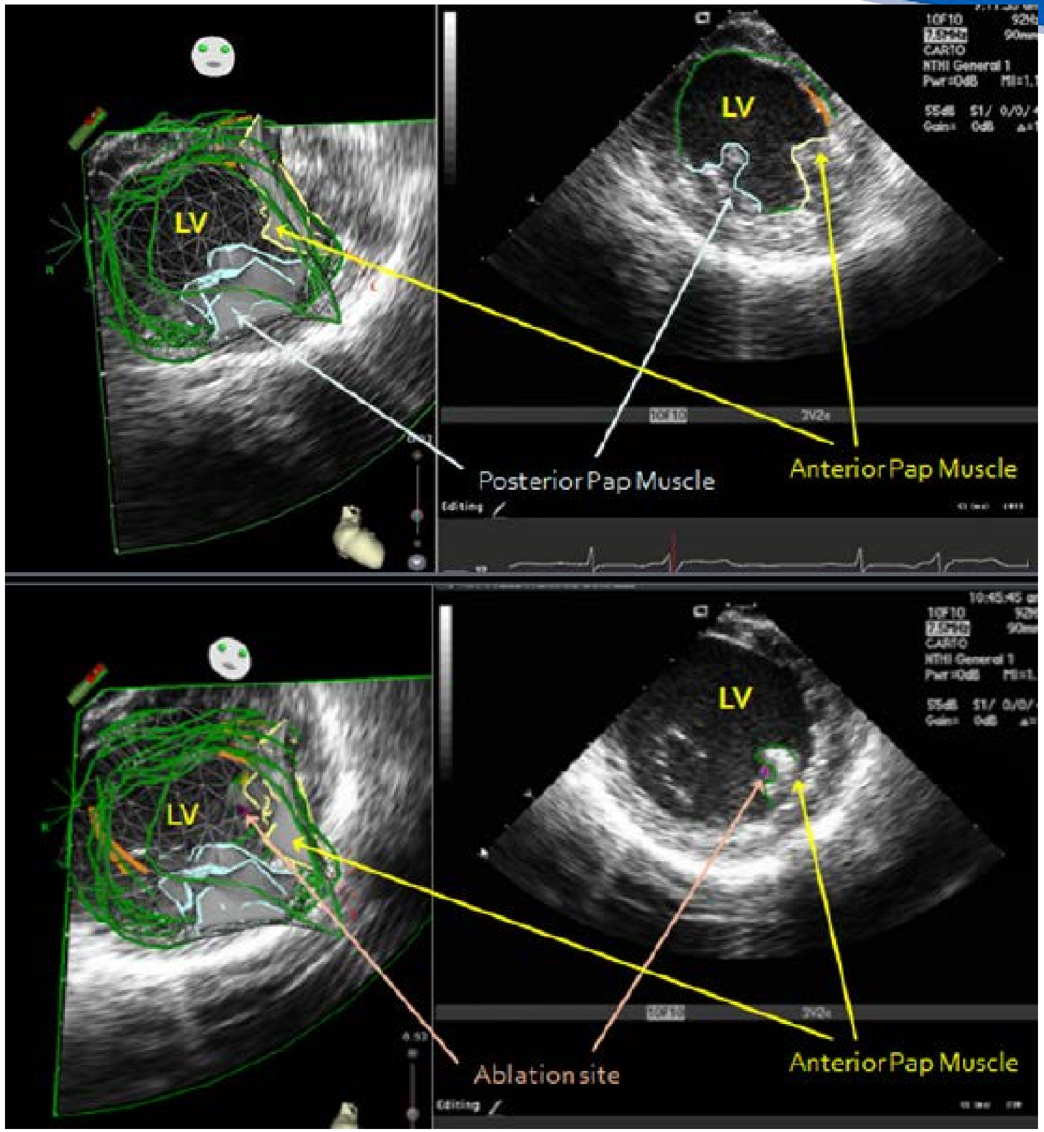


*REV ARGENT CARDIOL 2015;85:425-433.



Anterolateral PM muscle

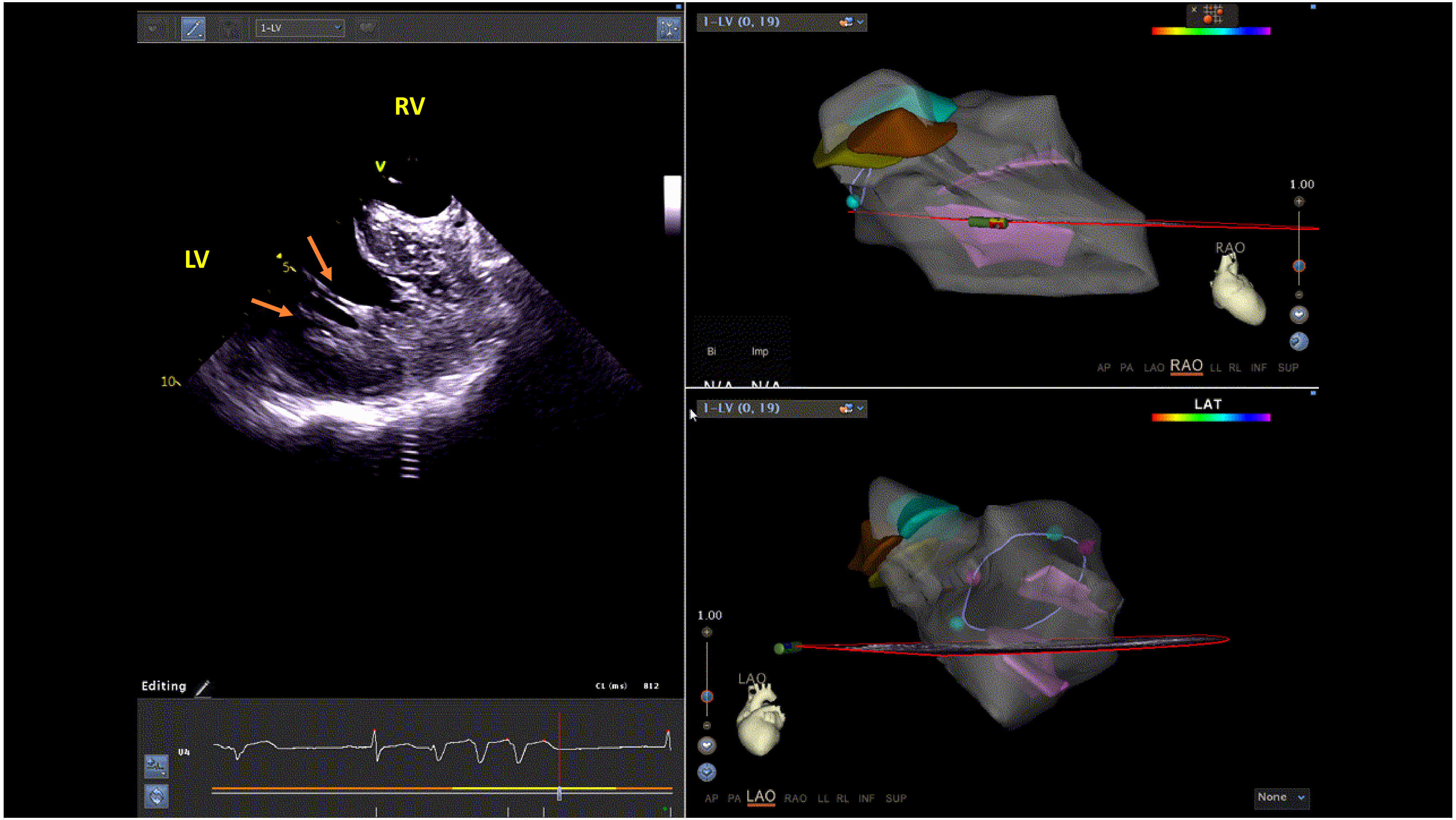
Posteromedial PM muscle

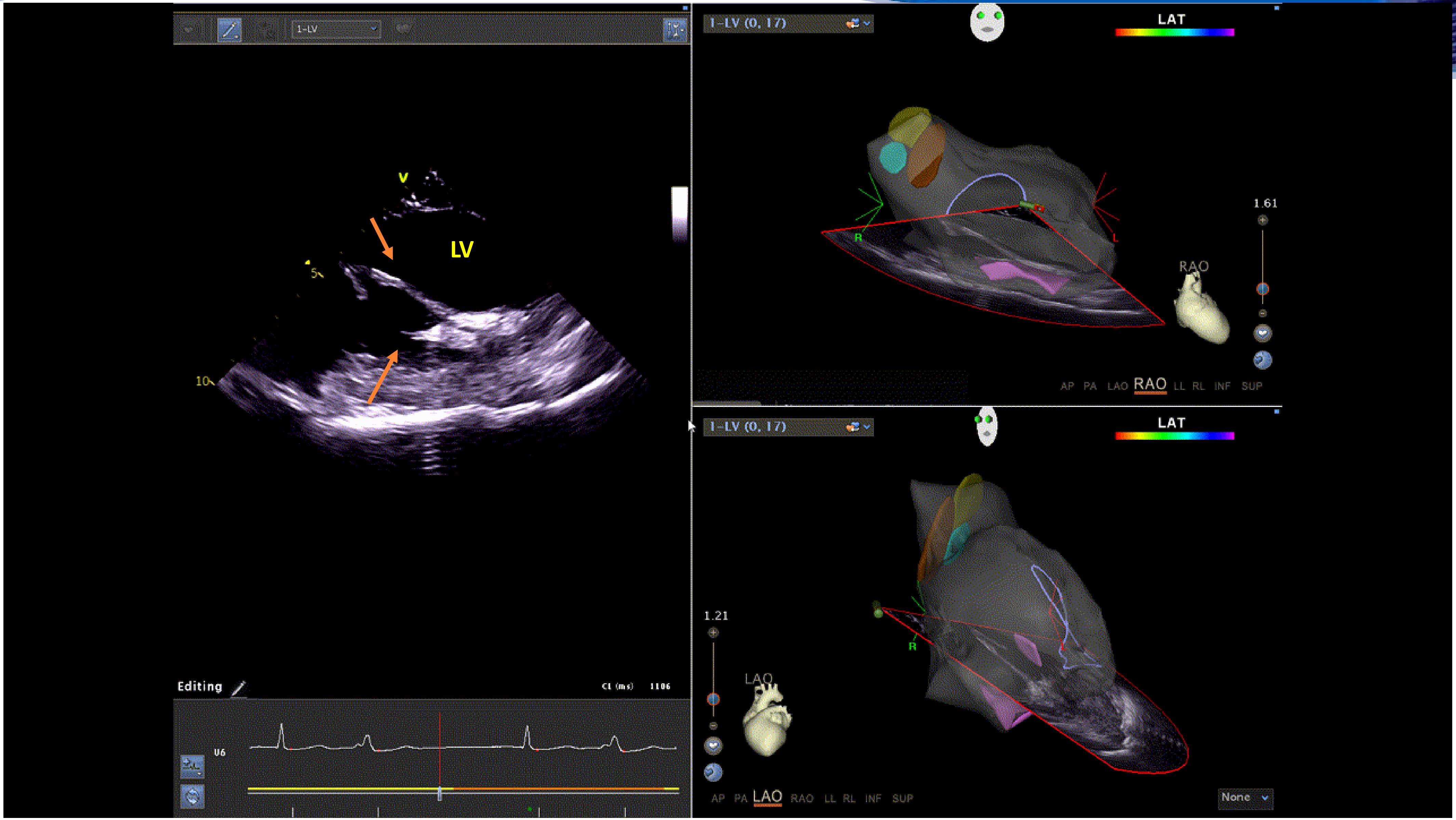


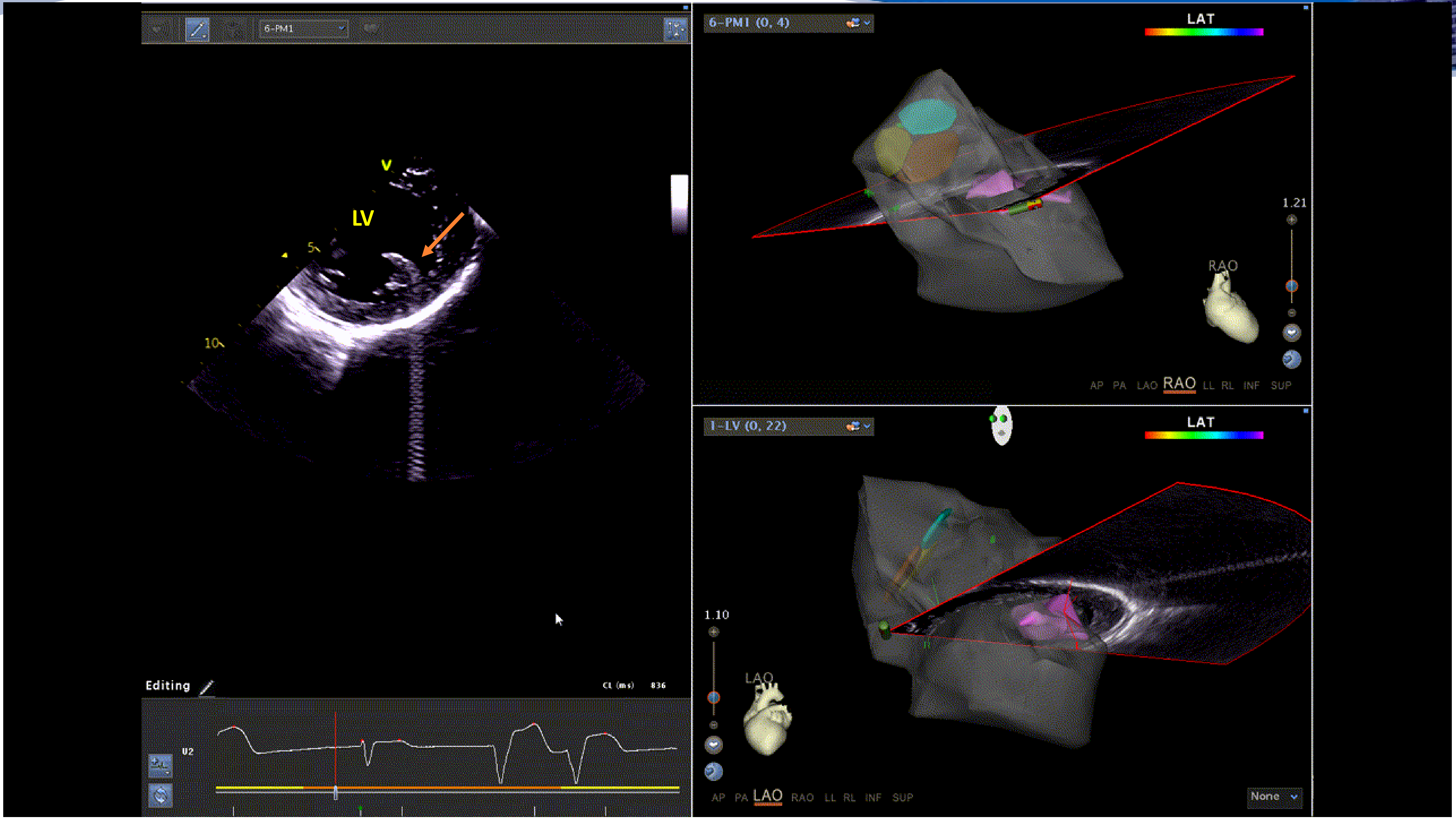
3D reconstruction of papillary muscle

*J Atr Fibrillation. 2014 Apr 30;6(6):1055.

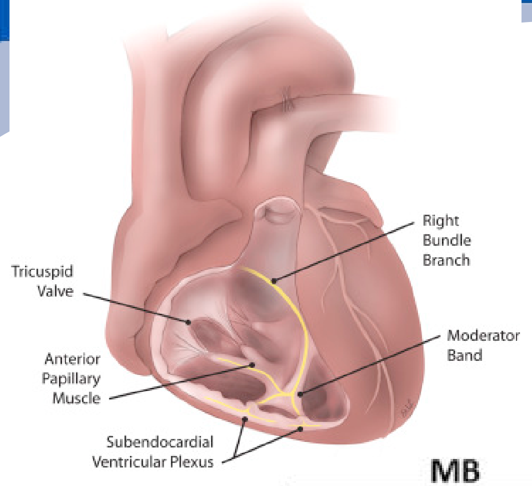
- **Real cases: papillary muscle**

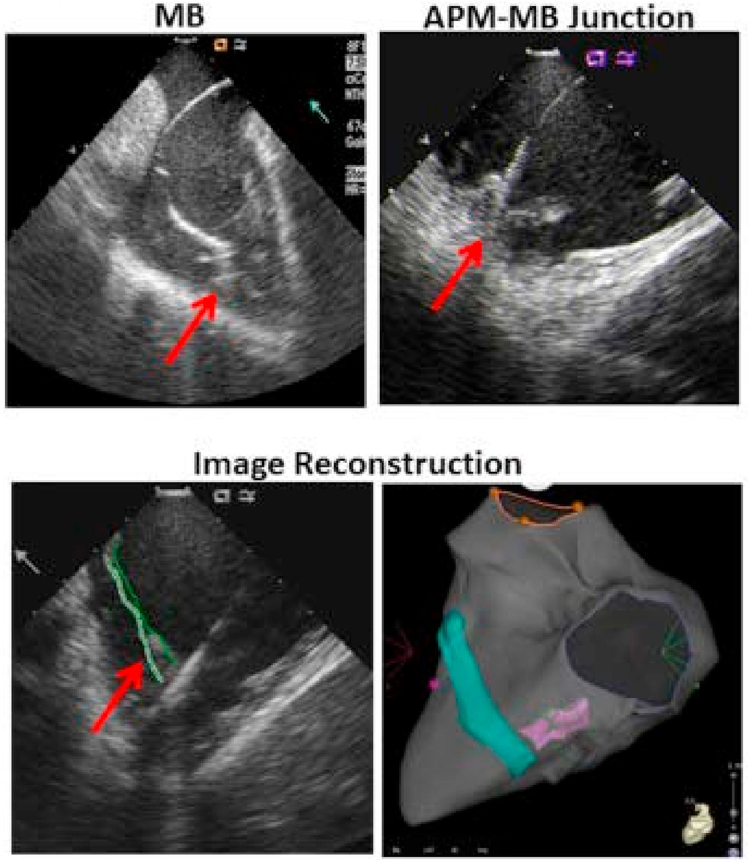


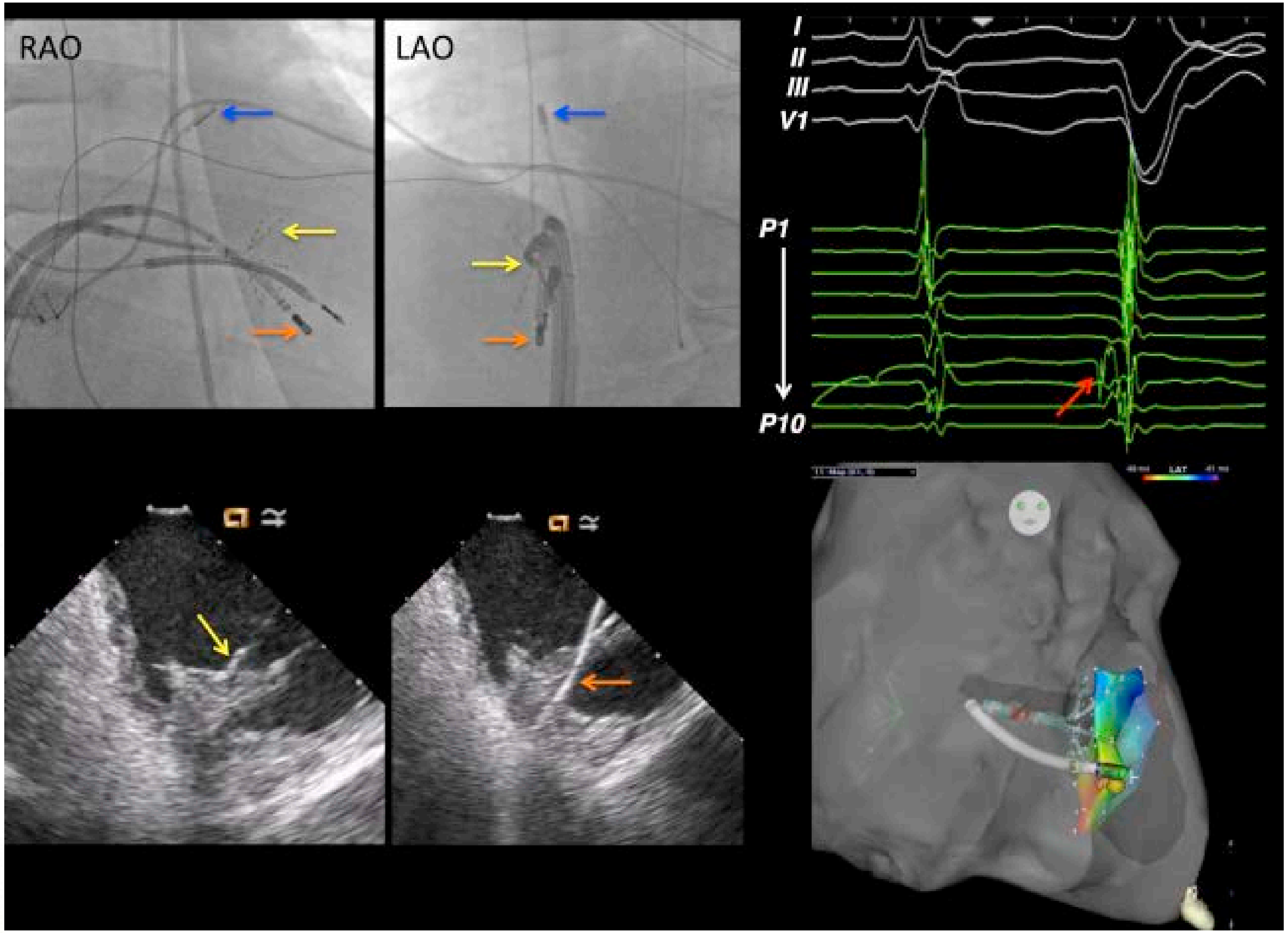

1-LV
LV
V
5
10
Editing
CL (ms) 1106
V6
1-LV (0, 17)
LAT
1.61
RAO
AP PA LAO RAO LL RL INF SUP
1-LV (0, 17)
LAT
1.21
LAO
AP PA LAO RAO LL RL INF SUP
None



6-PM1
V
LV
5
10
Editing
CL (ms) 836
V2
6-PM1 (0, 4)
LAT
1.21
RAO
AP PA LAO RAO LL RL INF SUP
1-LV (0, 22)
LAT
1.10
LAO
AP PA LAO RAO LL RL INF SUP
None

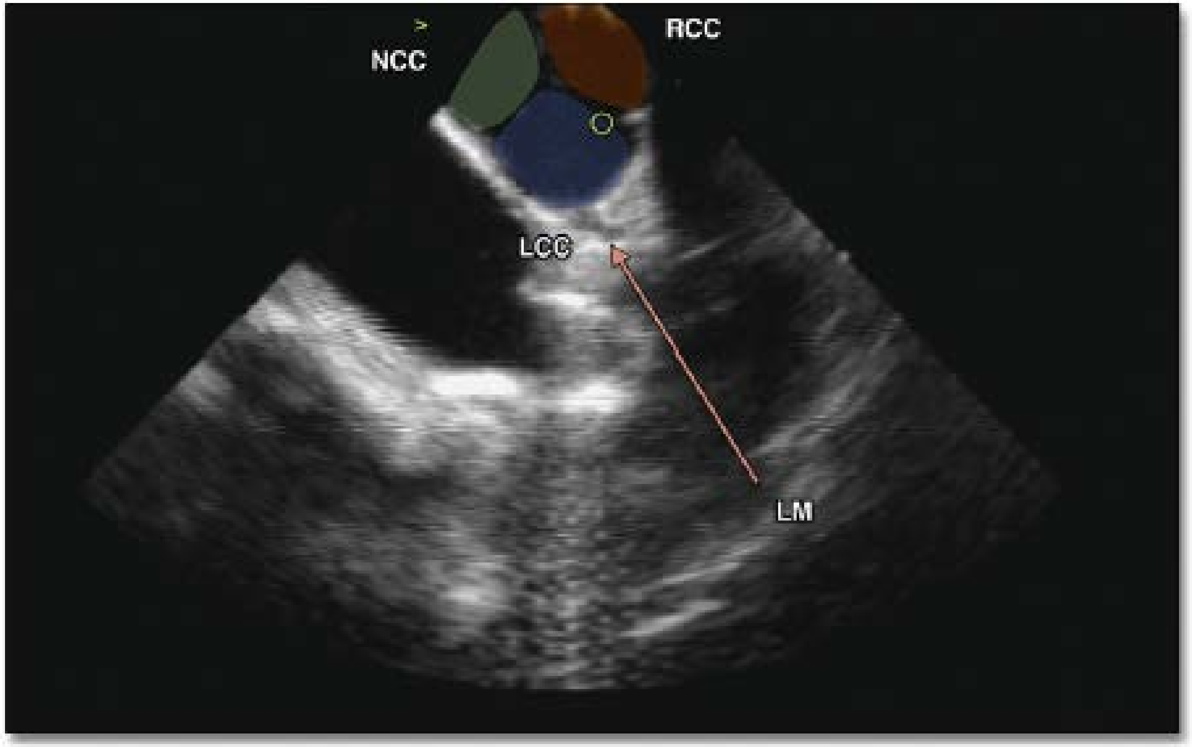






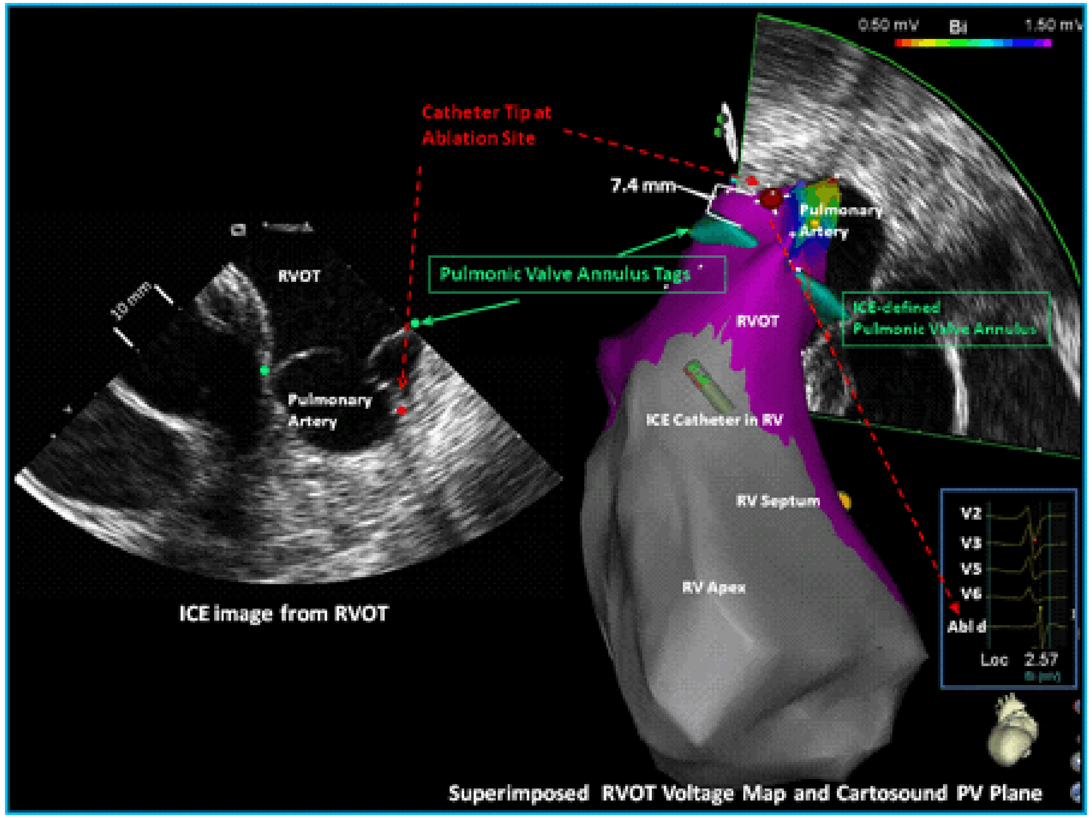
Heart Rhythm. 2015 Jan;12(1):67-75.

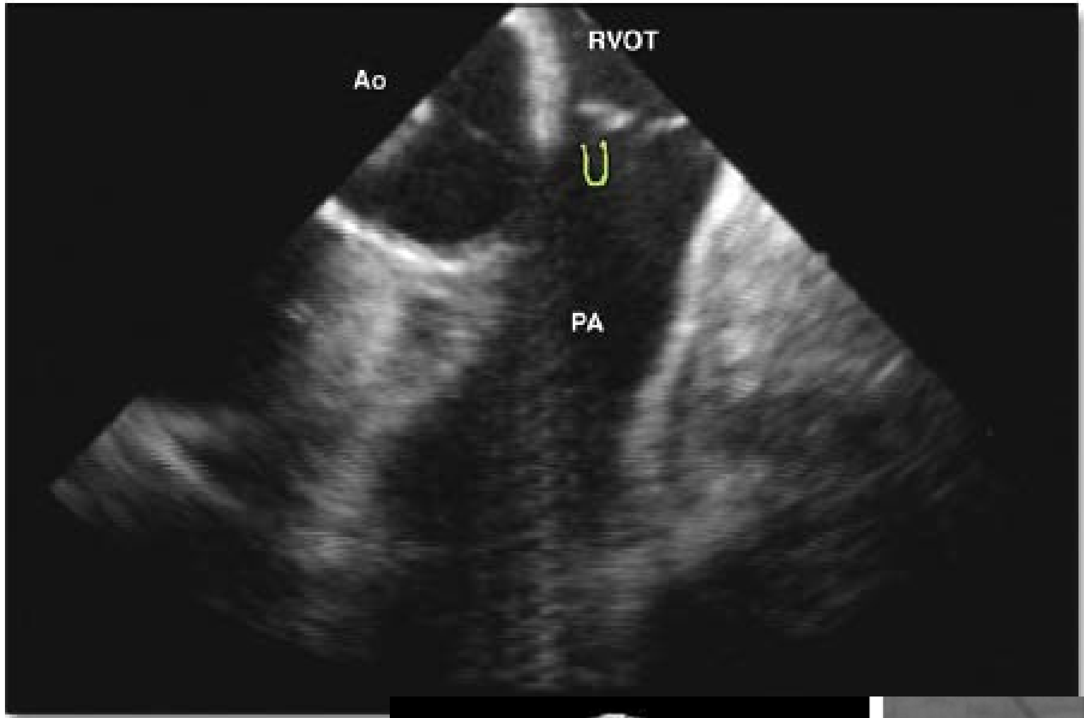
- Constant monitoring of the catheter tip on the real-time echocardiogram helps to make sure that there is a safe distance between the target location and the adjacent critical structures.

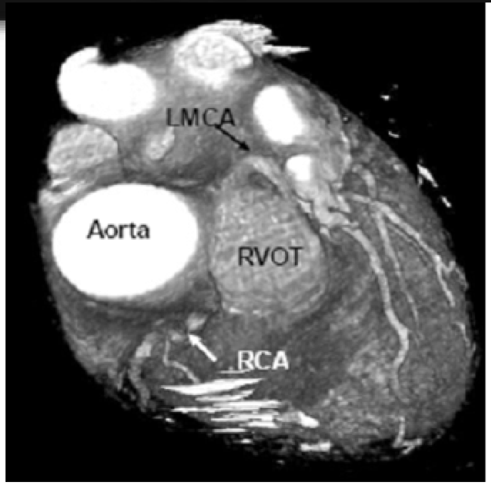


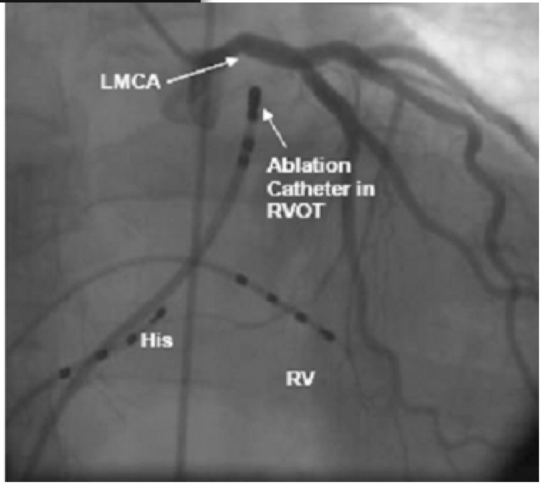
*JACC Cardiovasc Imaging. 2016 Jul;9(7):873-886.

- Anatomical confirmation of the origin and avoidance of the epicardial coronary artery in VT originating from pulmonary artery musculature



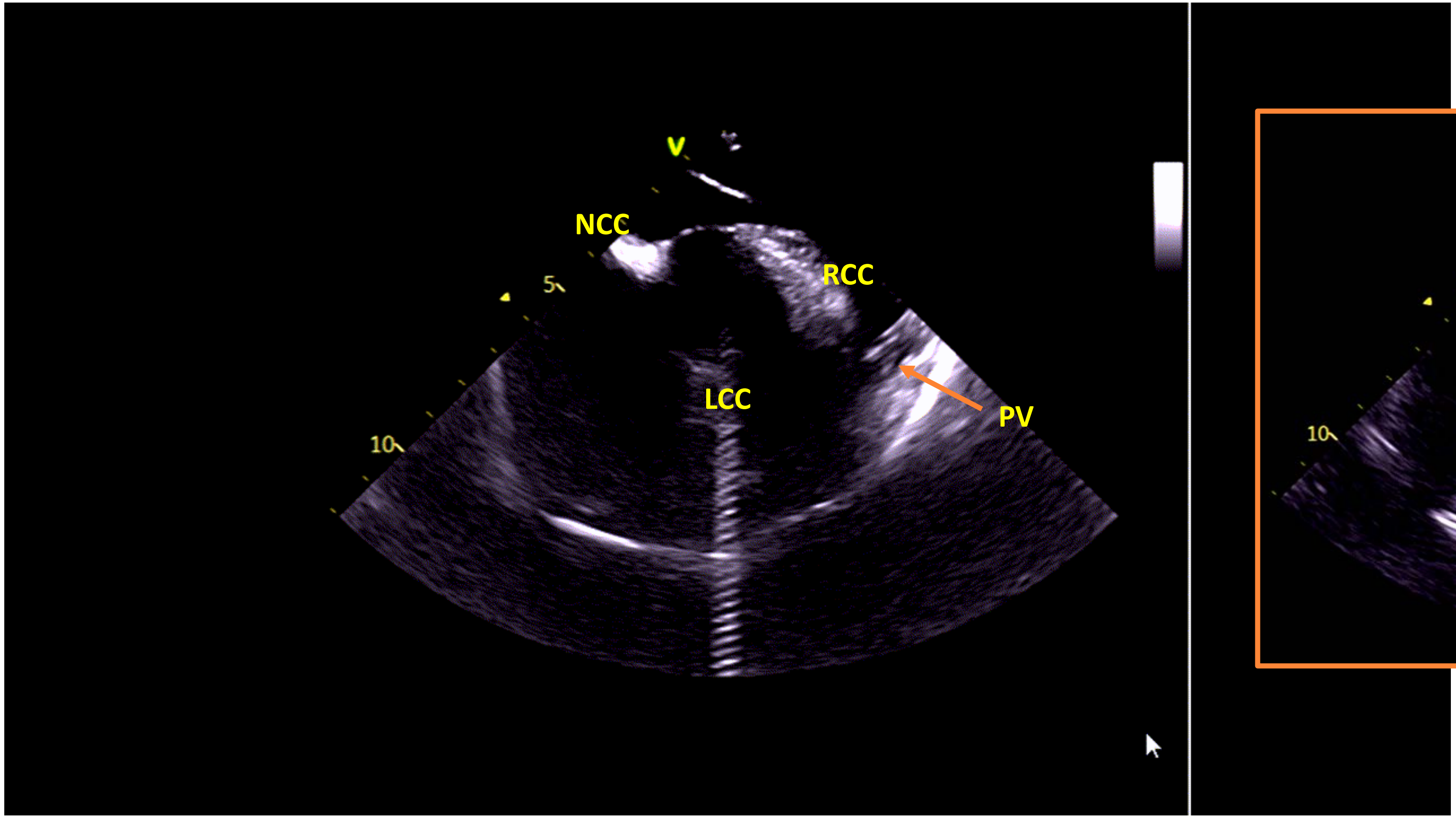


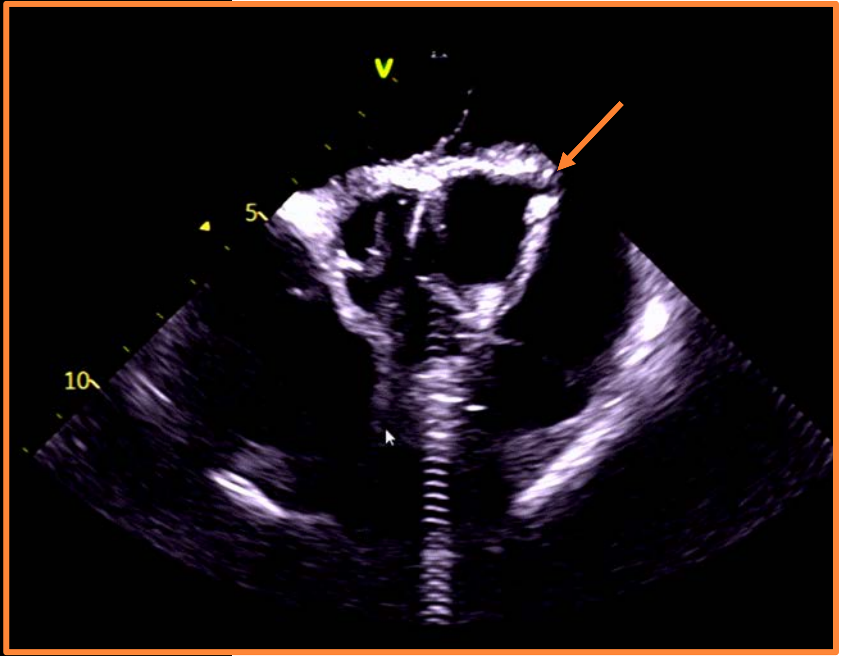


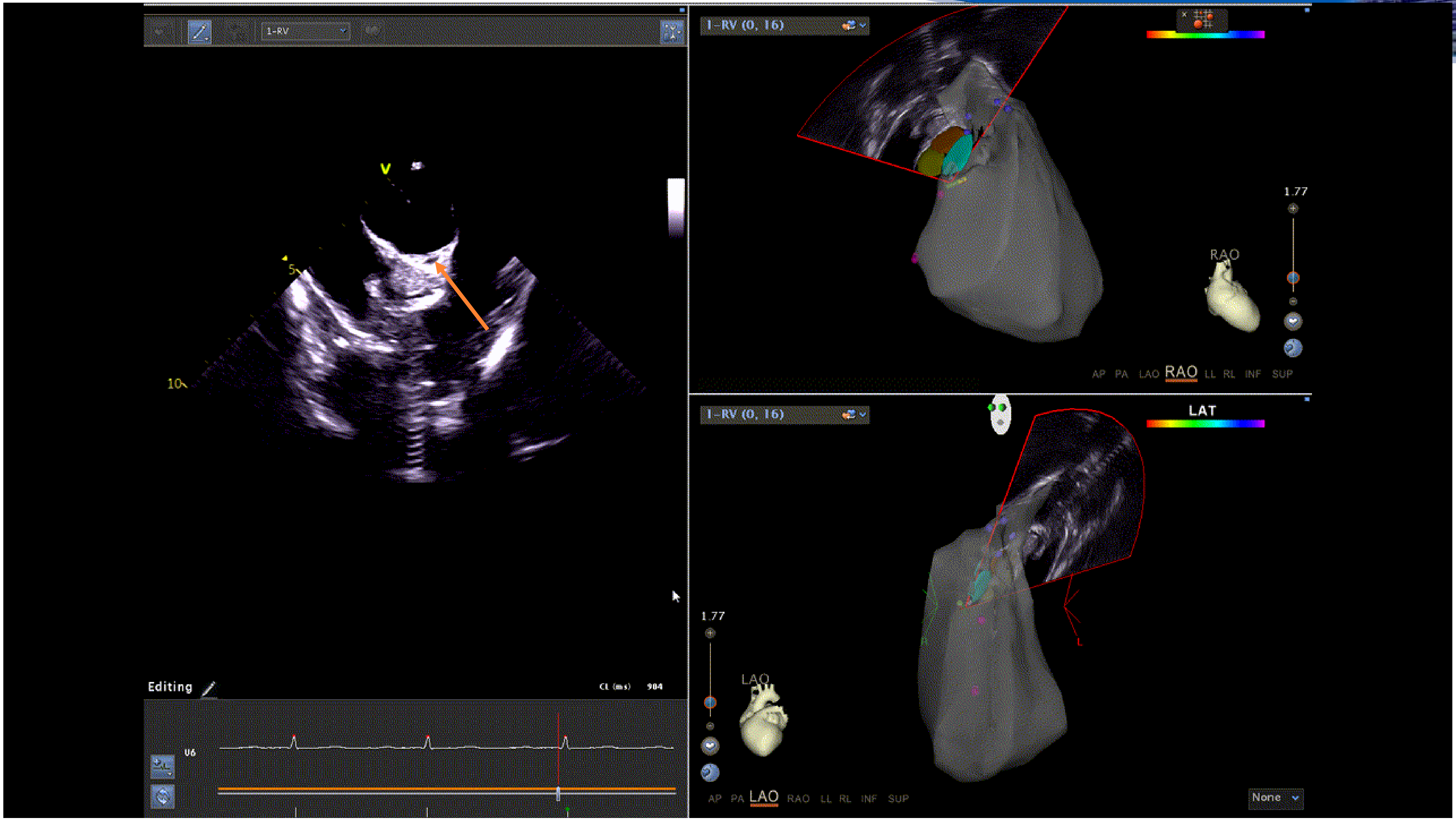


*Circulation. 2012;126:A14828. J Cardiovasc Electrophysiol. 2010;21:678-684.
JACC Cardiovasc Imaging. 2016 Jul;9(7):873-886.
J Cardiovasc Electrophysiol. 2006 Jun;17(6):632-7.

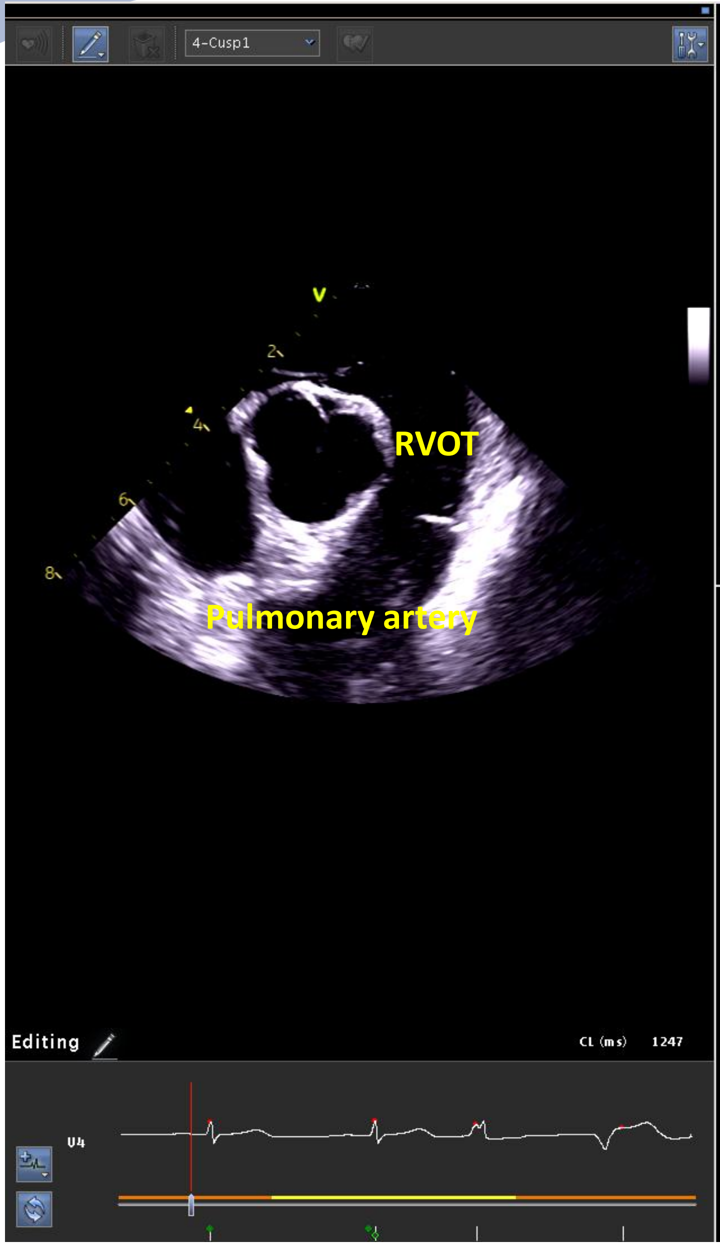
- **Real cases: Aortic cusp and coronary ostium**

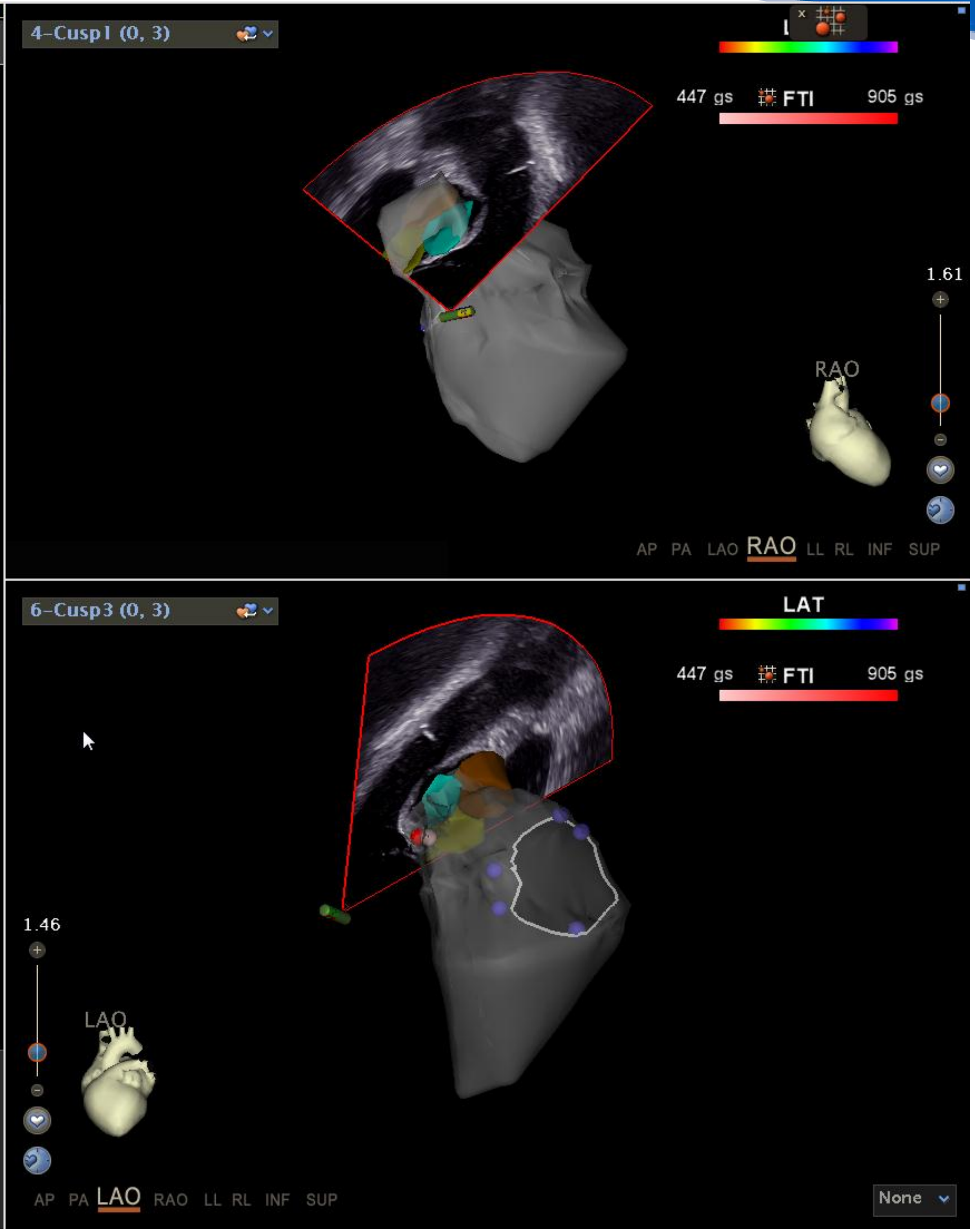


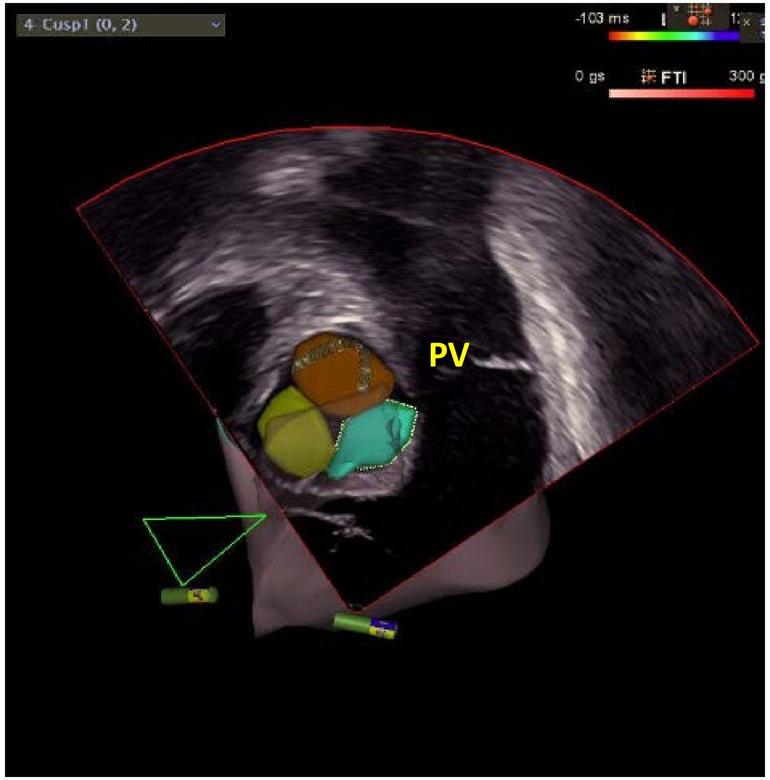




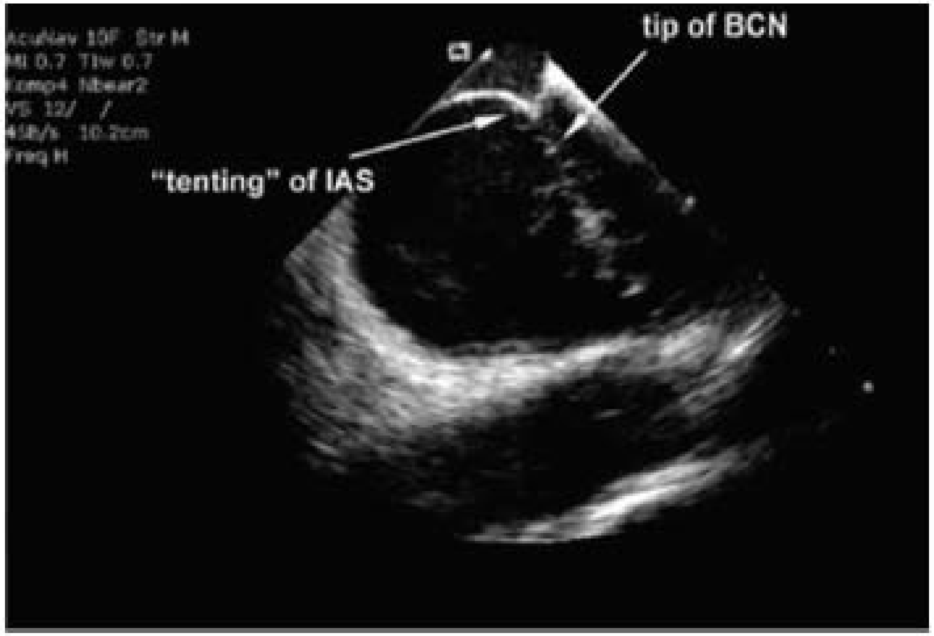
1-RV
Editing
CL (ms) 904
V6
1-RV (0, 16)
1.77
RAO
AP PA LAO RAO LL RL INF SUP
1-RV (0, 16)
LAT
1.77
LAO
AP PA LAO RAO LL RL INF SUP
None


4-Cusp1
V
RVOT
Pulmonary artery
Editing
CL (ms) 1247
V4

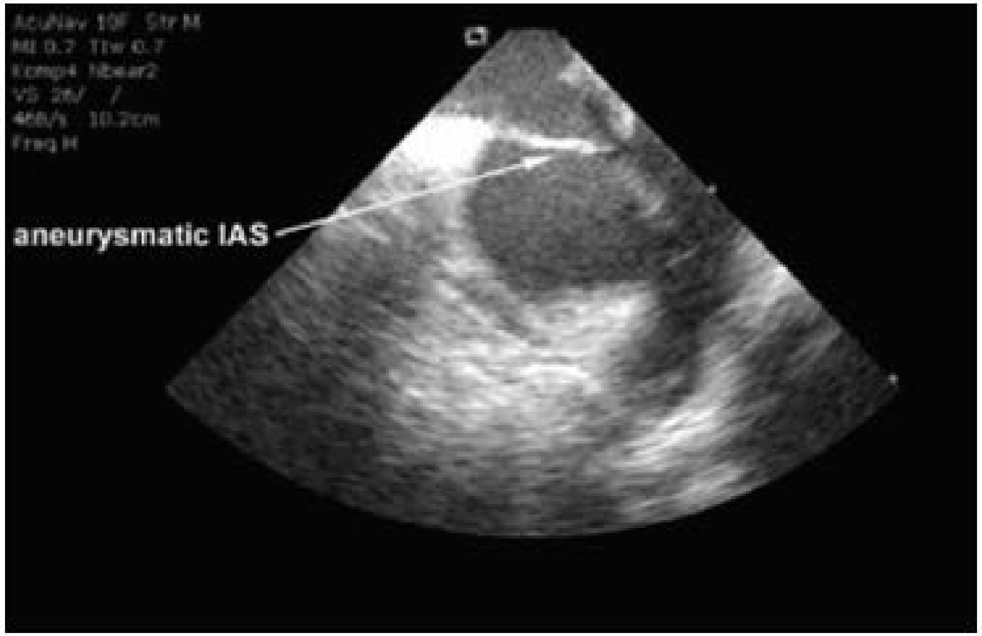

4-Cusp1 (0, 3)
447 gs FTI 905 gs
1.61
RAO
AP PA LAO RAO LL RL INF SUP
6-Cusp3 (0, 3)
LAT
447 gs FTI 905 gs
1.46
LAO
AP PA LAO RAO LL RL INF SUP
None


4-Cusp1 (0, 2)
-103 ms
0 gs FTI
PV

- ICE helps to guide trans-septal puncture. It is especially useful for patients with abnormal interatrial septum (thick, double membrane or aneurysmatic floppy septum; patent foramen ovale or atrial septal defect; lipomatous hypertrophy of the septum; previous cardiac surgery with distorted anatomy or thickened septum; after device closure of an atrial septal defect)



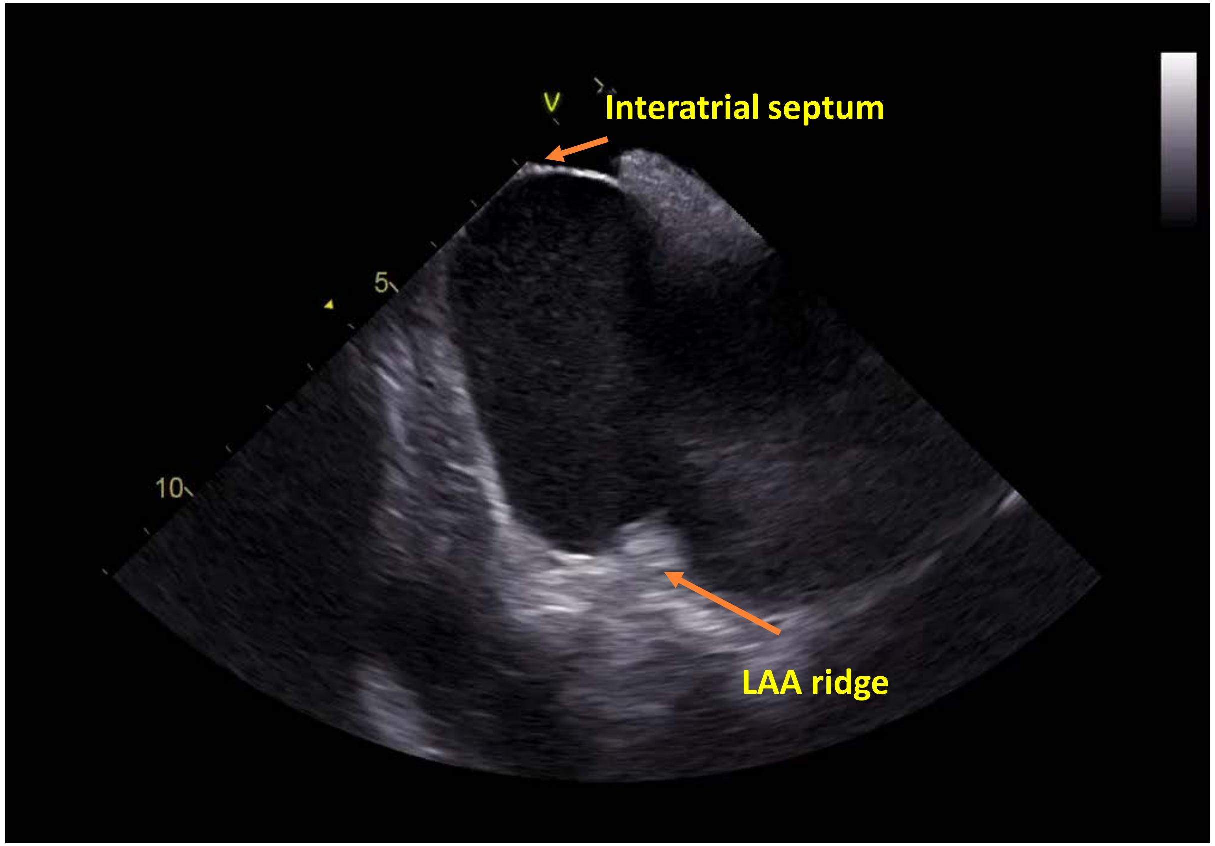
Advancement of needle into LA

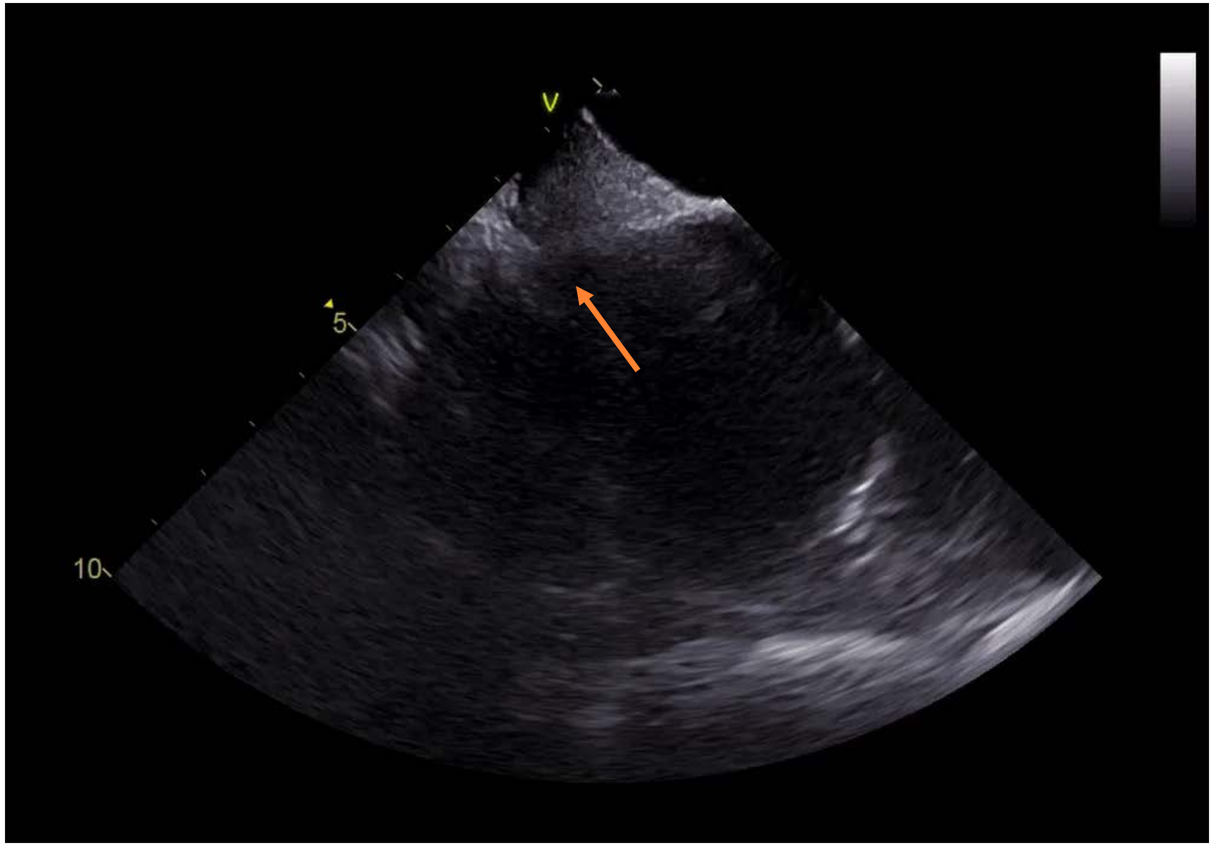


Aneurysmatic septum

*Cardiol Res Pract. 2012;2012:921746.

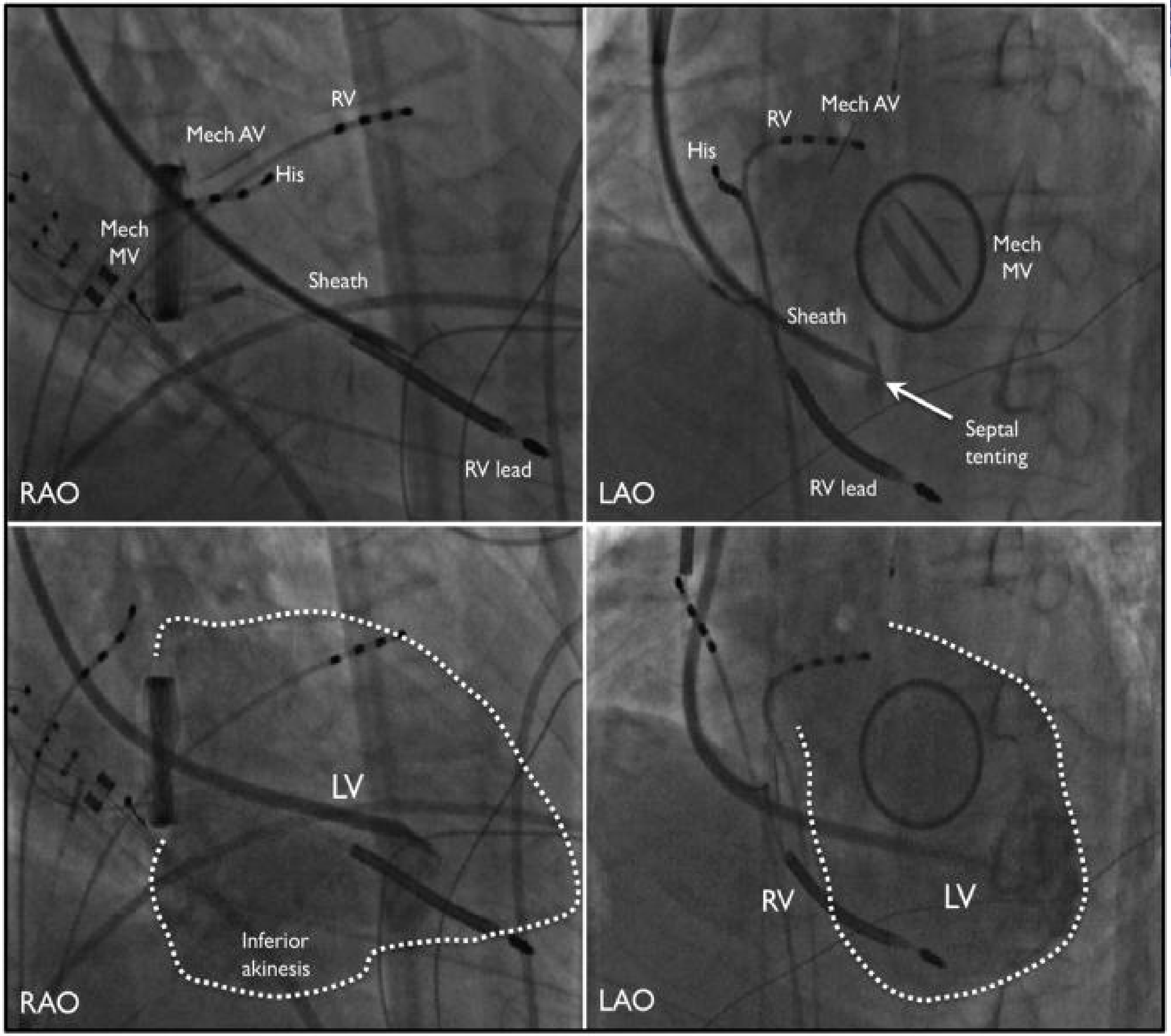
- **Real case: trans-septal puncture**



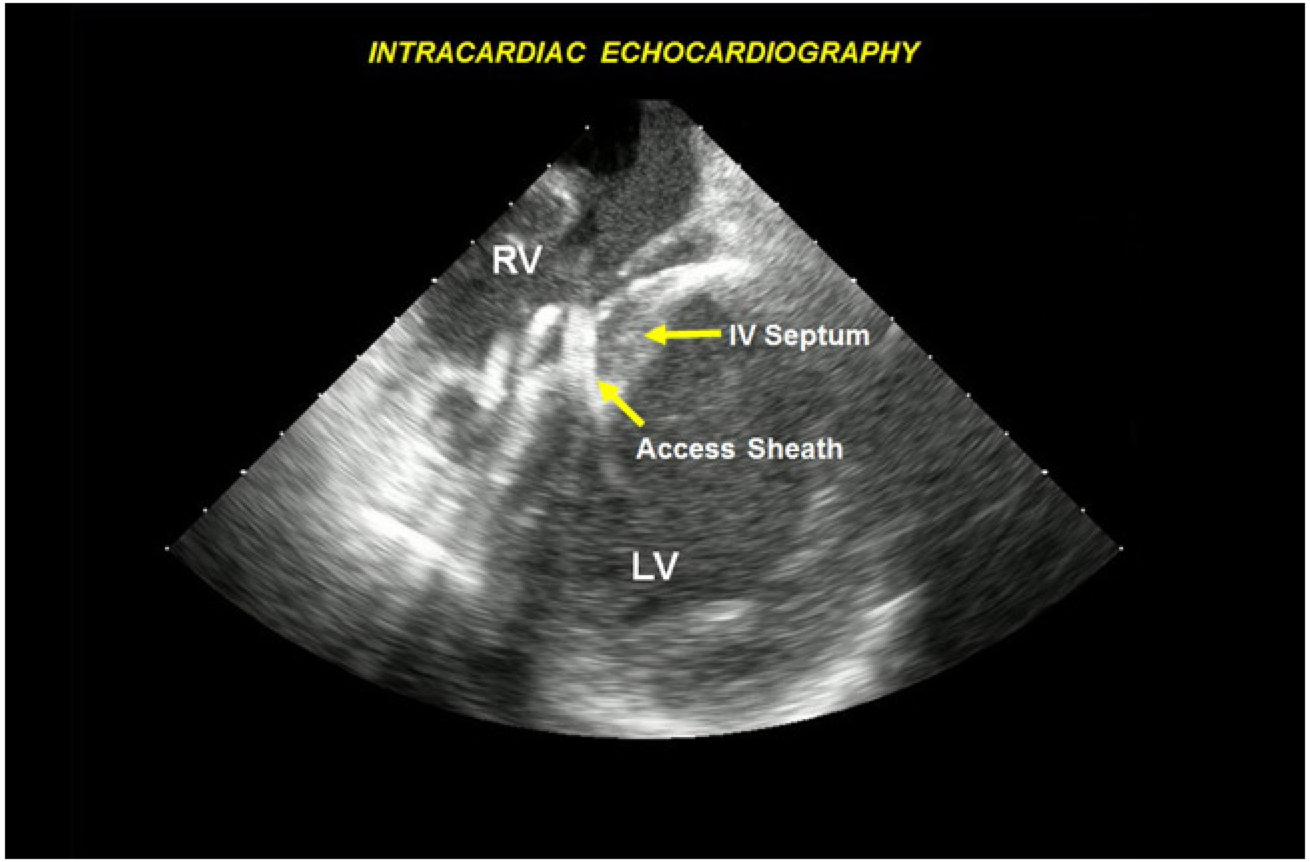


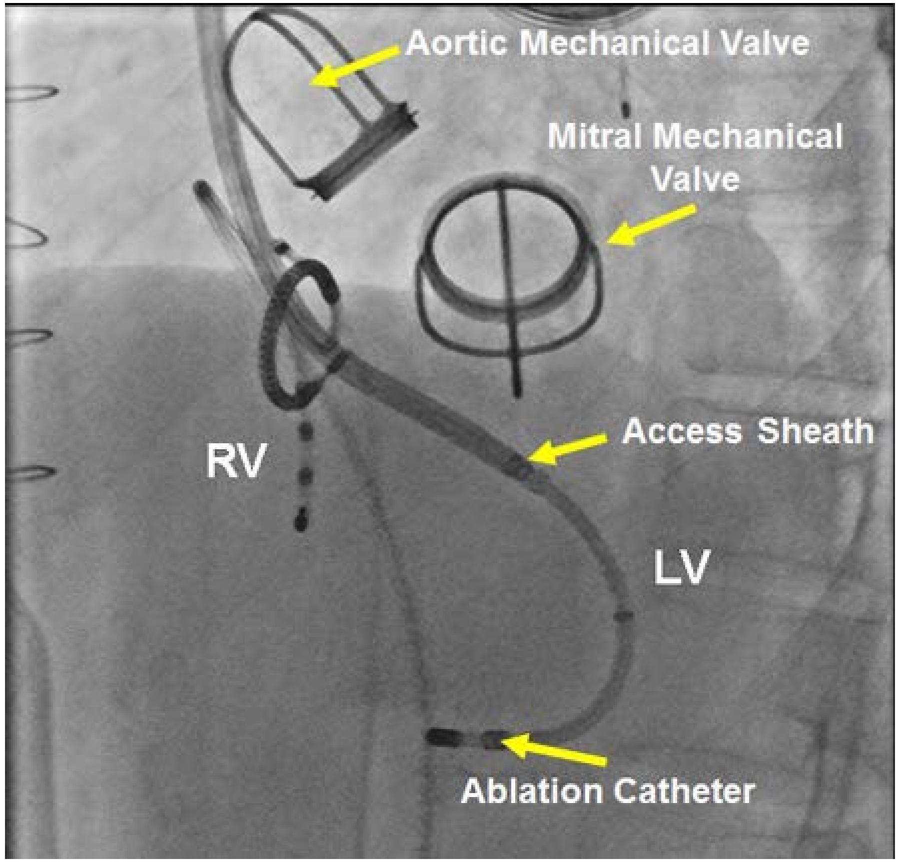
Tented inter-atrial septum

- Percutaneous Inter-Ventricular Septal Access in a Patient with Aortic and Mitral Mechanical Valves

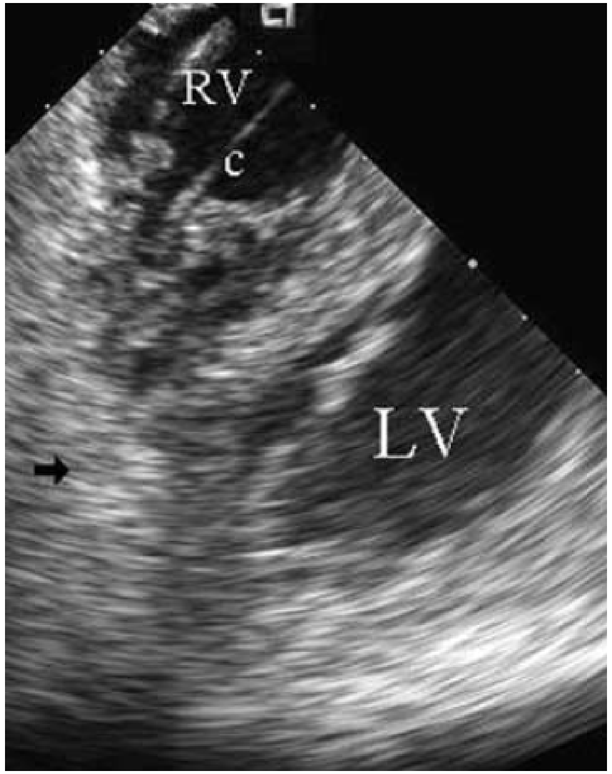


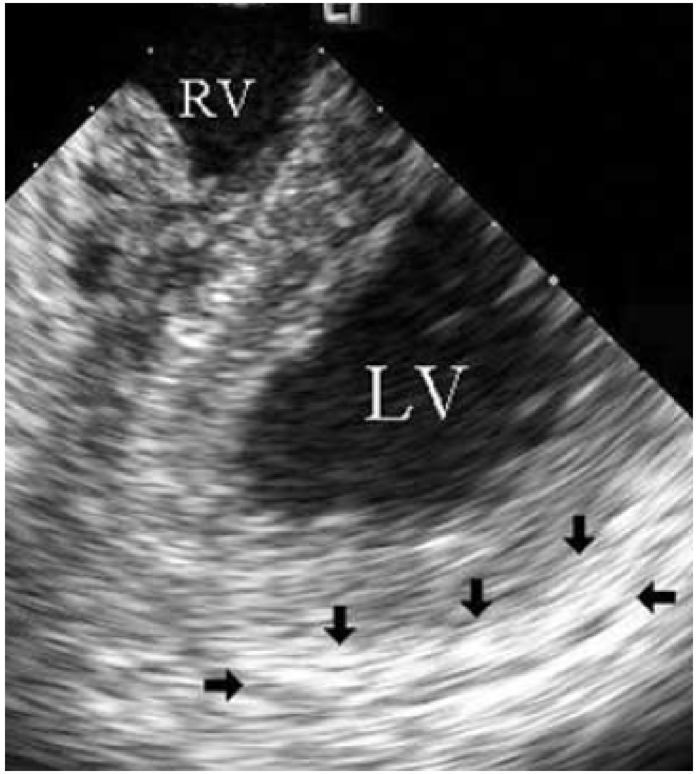
*Heart Rhythm. 2013 Jul; 10(7): 1069–1073.


INTRACARDIAC ECHOCARDIOGRAPHY
RV
IV Septum
Access Sheath
LV


Aortic Mechanical Valve
Mitral Mechanical Valve
Access Sheath
RV
LV
Ablation Catheter

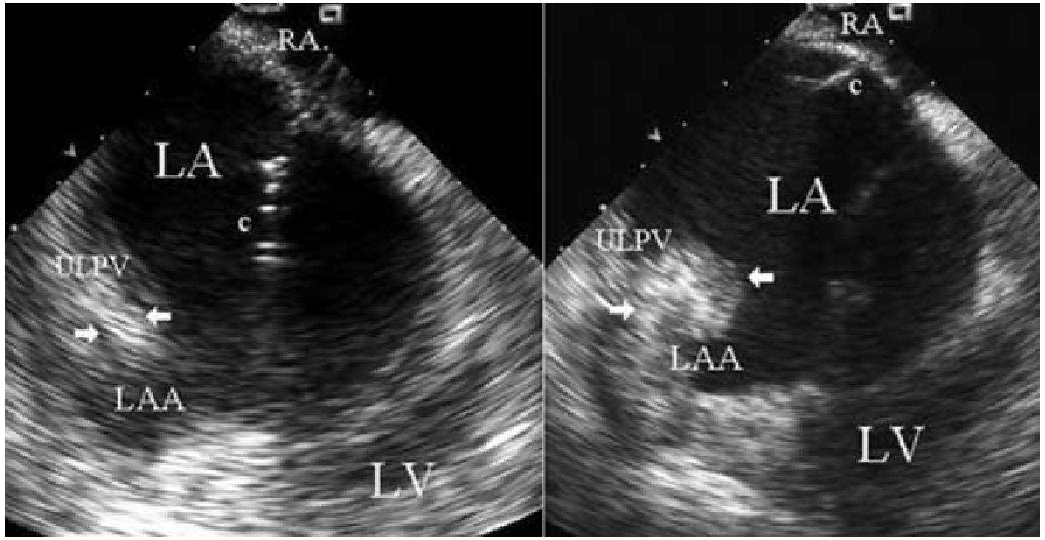
- ICE helps to guide the subxyphoid/subcostal pericardial puncture.
  - Rapid identification of unexpected needle puncture passing through the ventricle
  - Monitoring of catheter tip position and lesion morphologic change

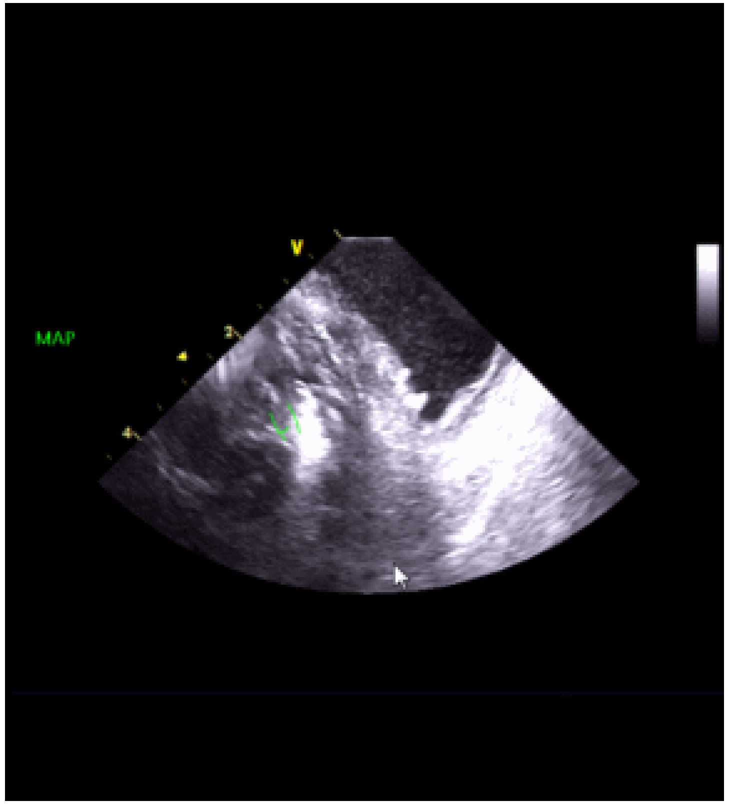




*Echocardiography 2007;24:533– 400

- ICE can provide imaging of lesion morphologic changes (swelling, dimpling, crater formation, accelerated bubbles before popping-crater like lesion development, and increased echogenicity) → titration of energy power/ duration to control lesion formation and to prevent overheating
- The catheter-tissue contact can be monitored.



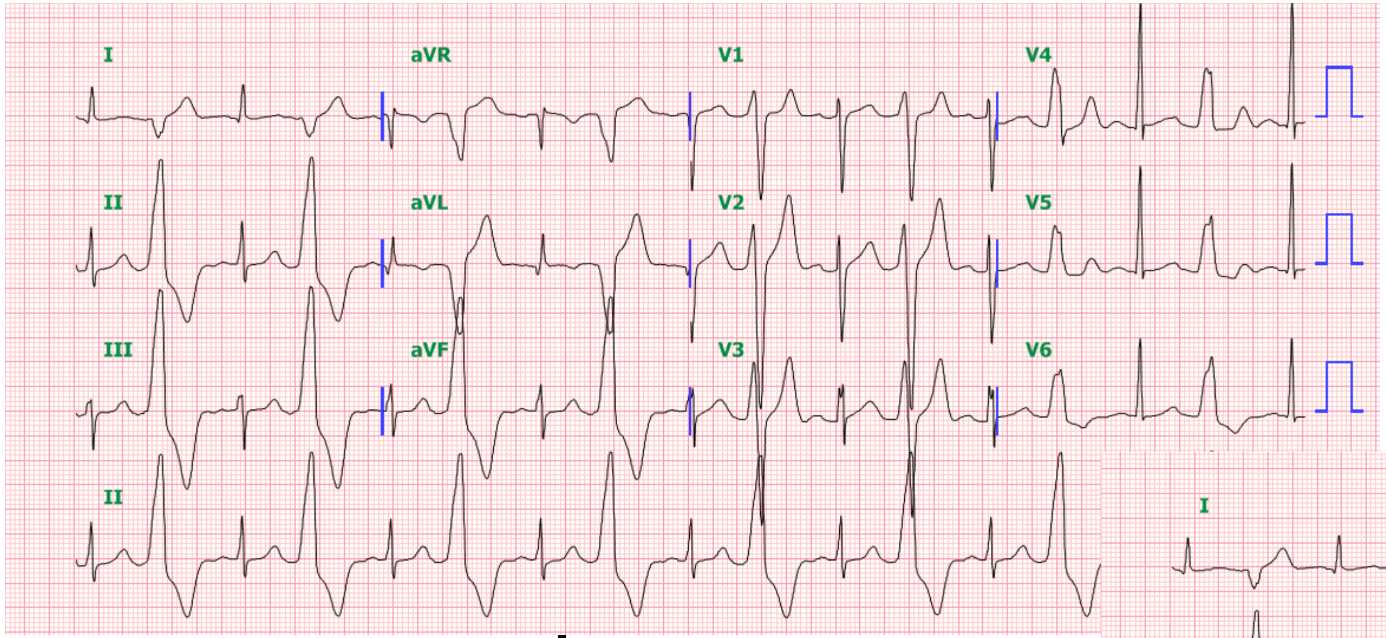


Real case : ablation lesion formation in LVOT

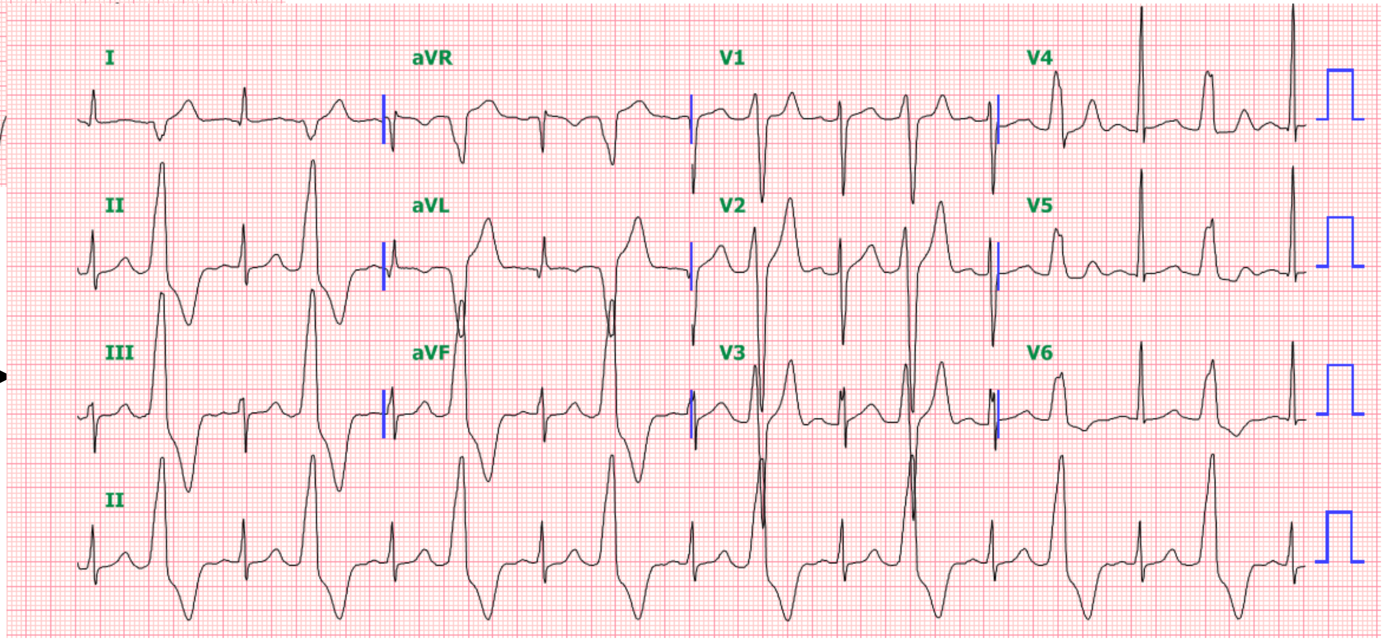
*Echocardiography 2007;24:533– 400

Summary case

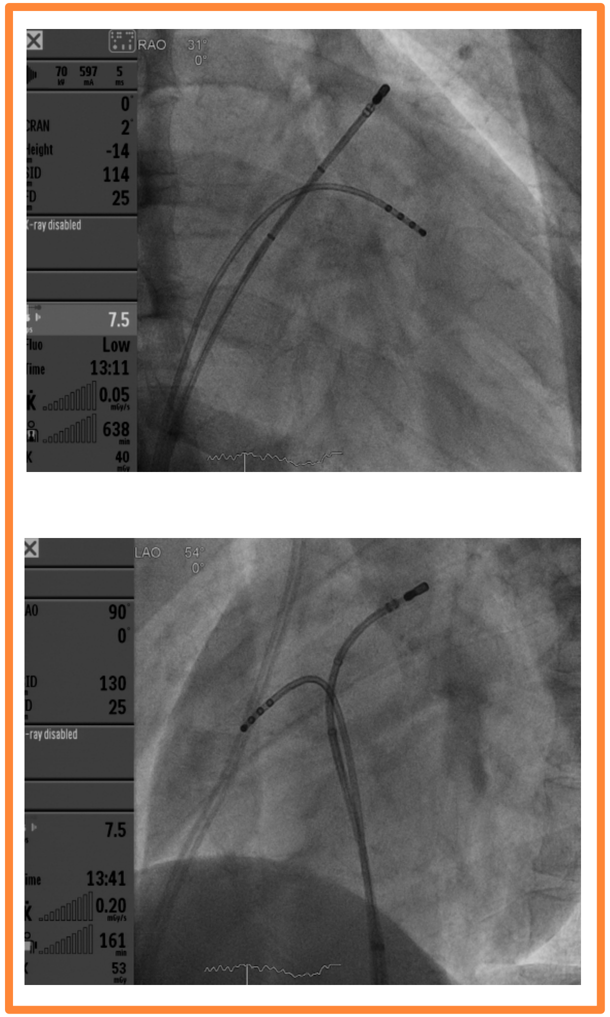
- **40-year old male with recurrent outflow tract VPCs**



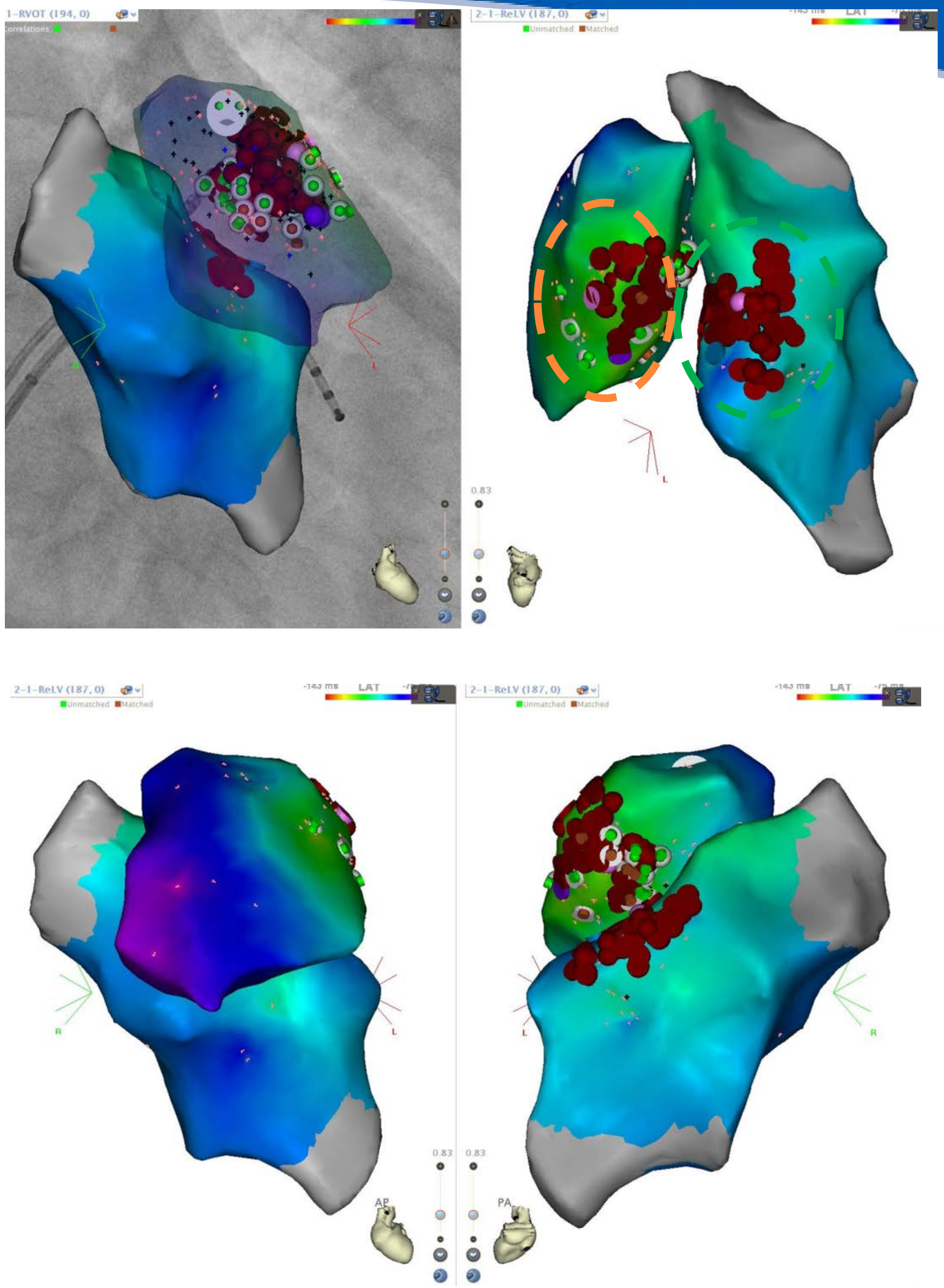
Recur at 1 month from the 1st ablation

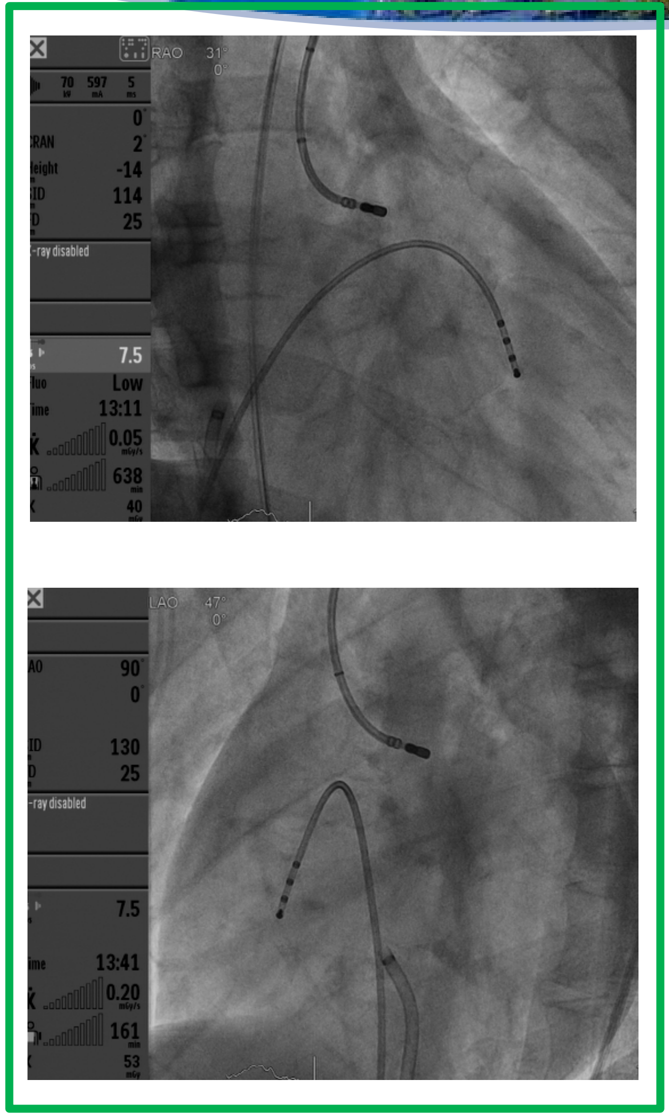


First ablation



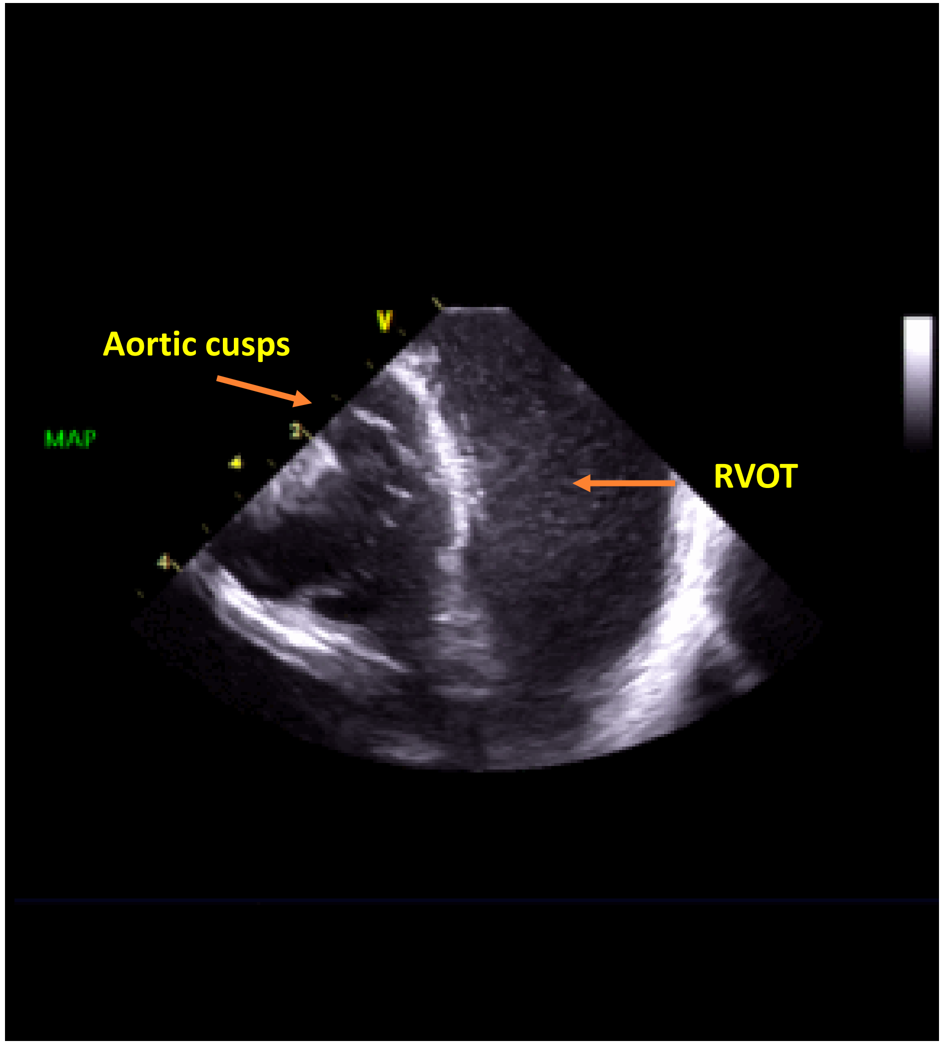
RVOT ablation site



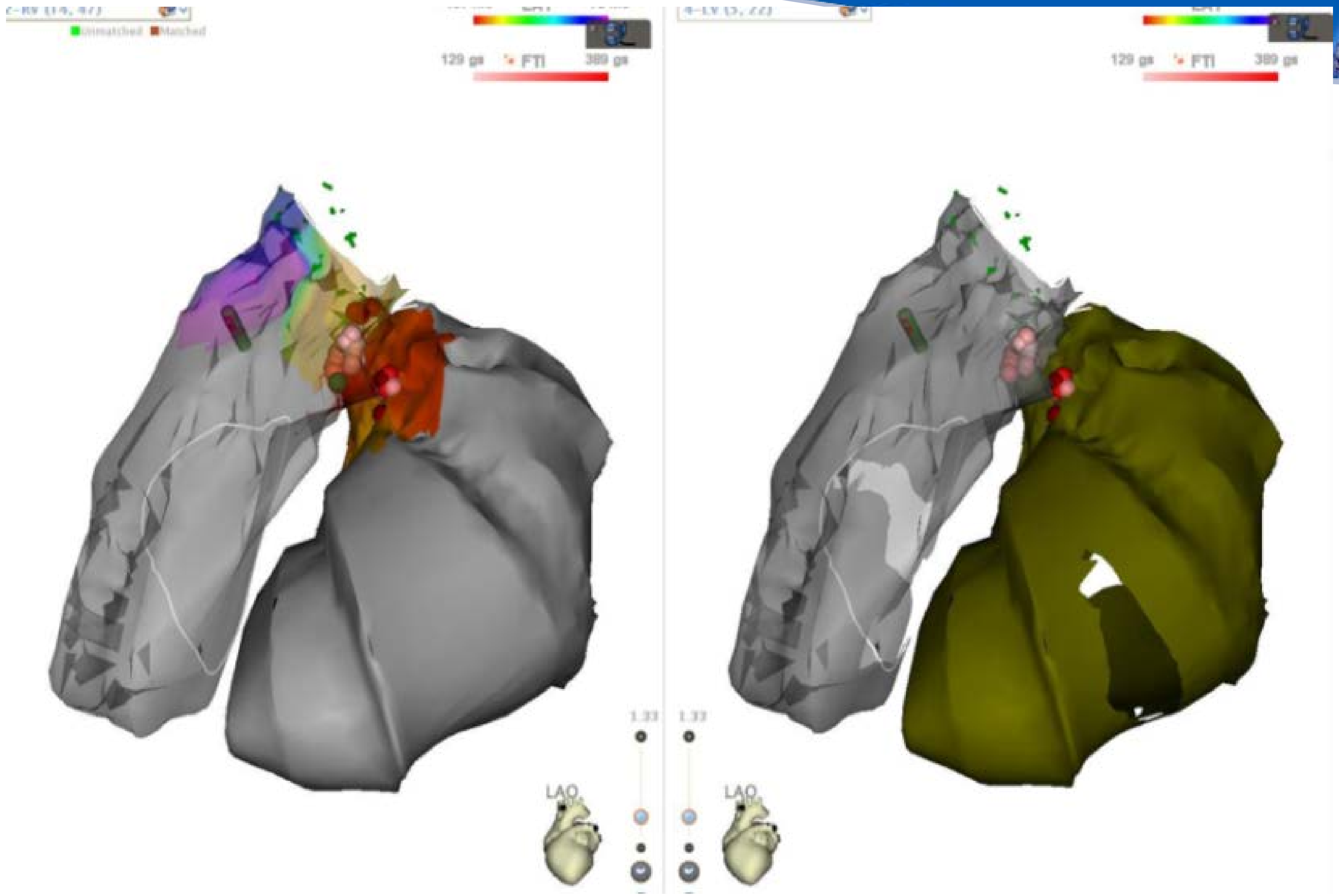


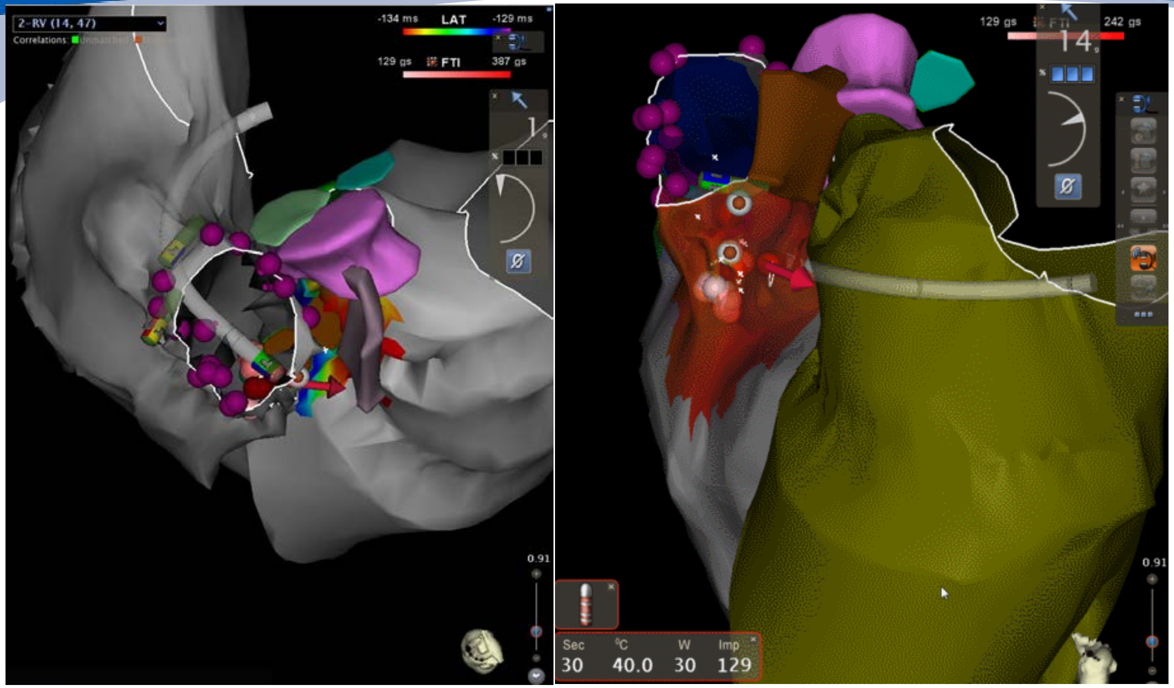
LVOT ablation site

2nd ablation

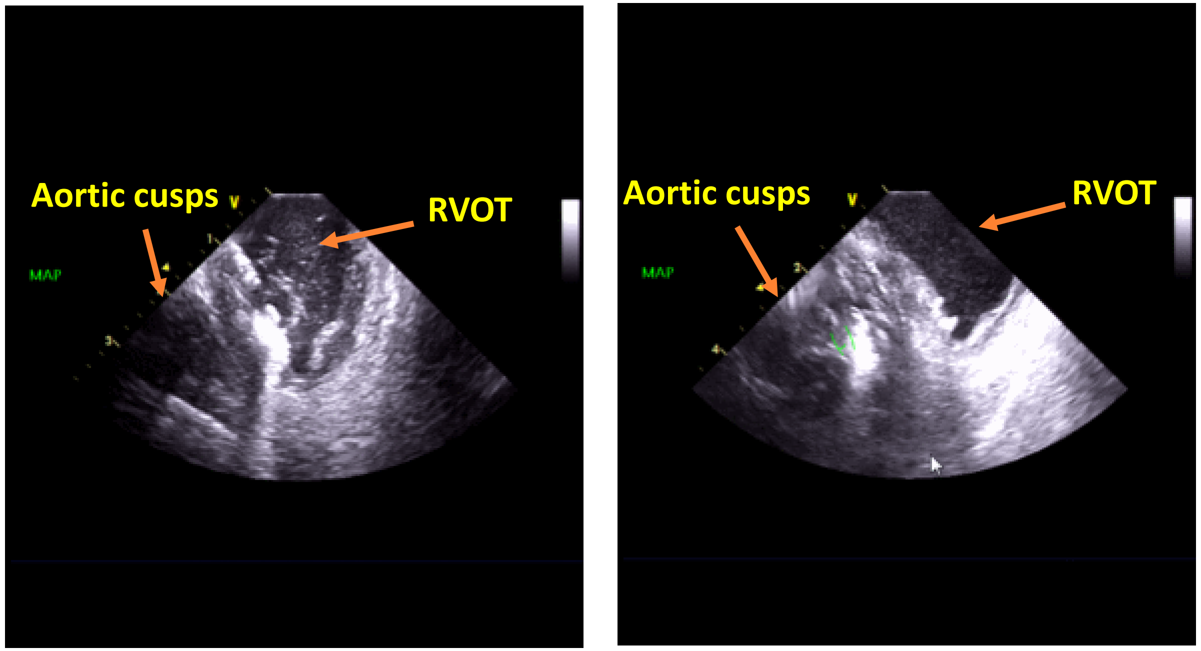


ICE-guided anatomic mapping of both ventricles


129 gs
FTI
389 gs
129 gs
FTI
389 gs
1.33
1.33
LAO
LAO



Ablation sites at the 2nd ablation



Role of ICE during VT ablation

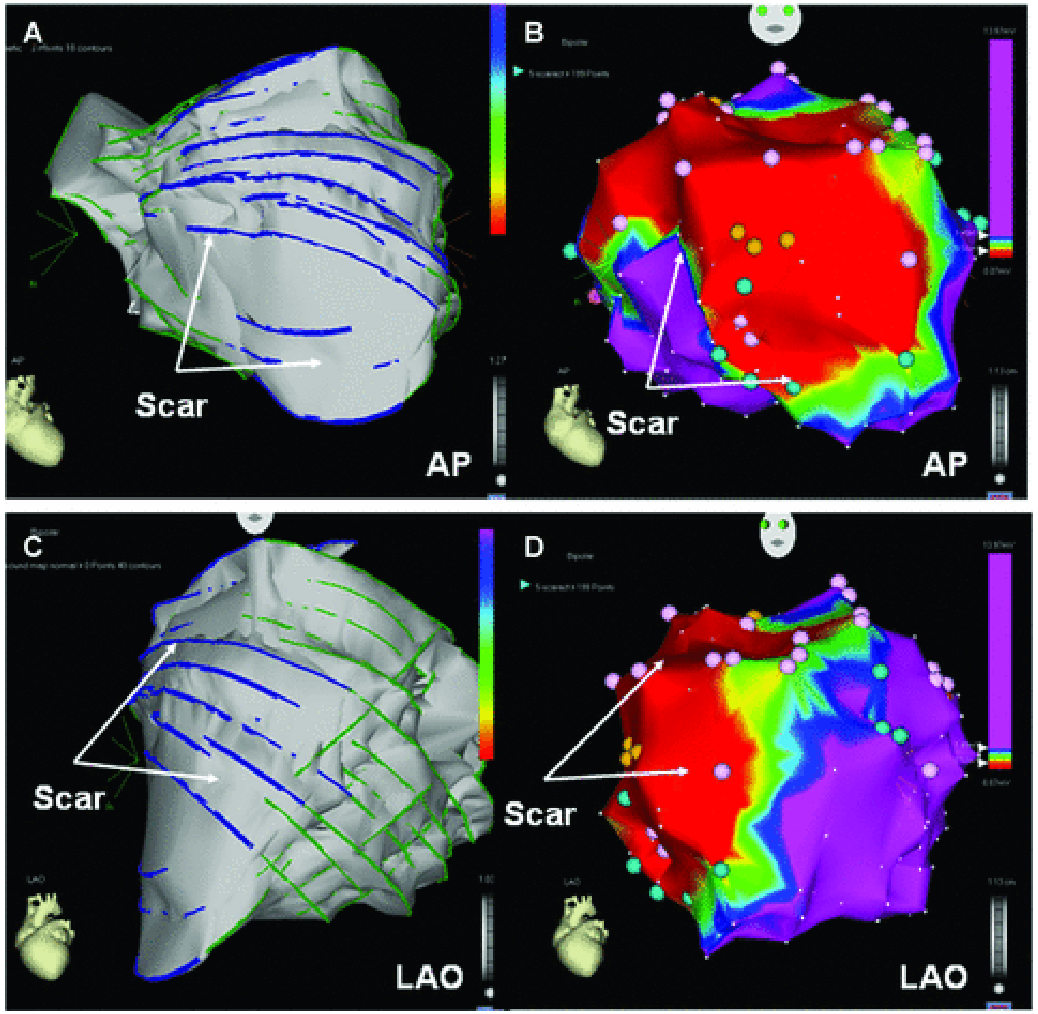
Direct visualization of anatomy, catheter, and lesion formation

Identification of substrate

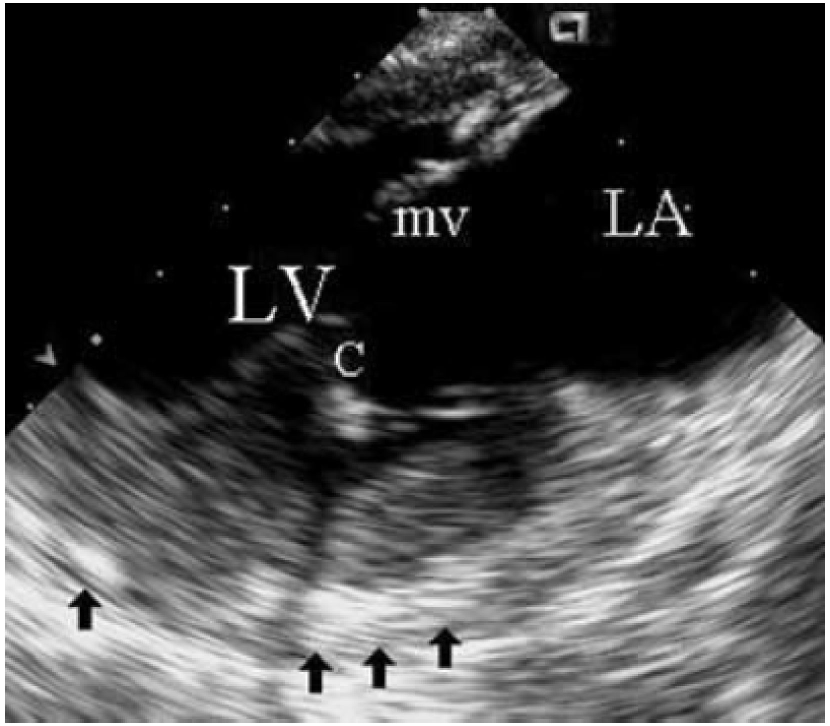
Continuous monitoring for complication

- Real time ICE images provide accurate chamber geometries and scar boundaries of the left ventricle. These scar borders were more accurate than transthoracic echocardiography and illustrate the feasibility of ICE for substrate-based ablation for VT.

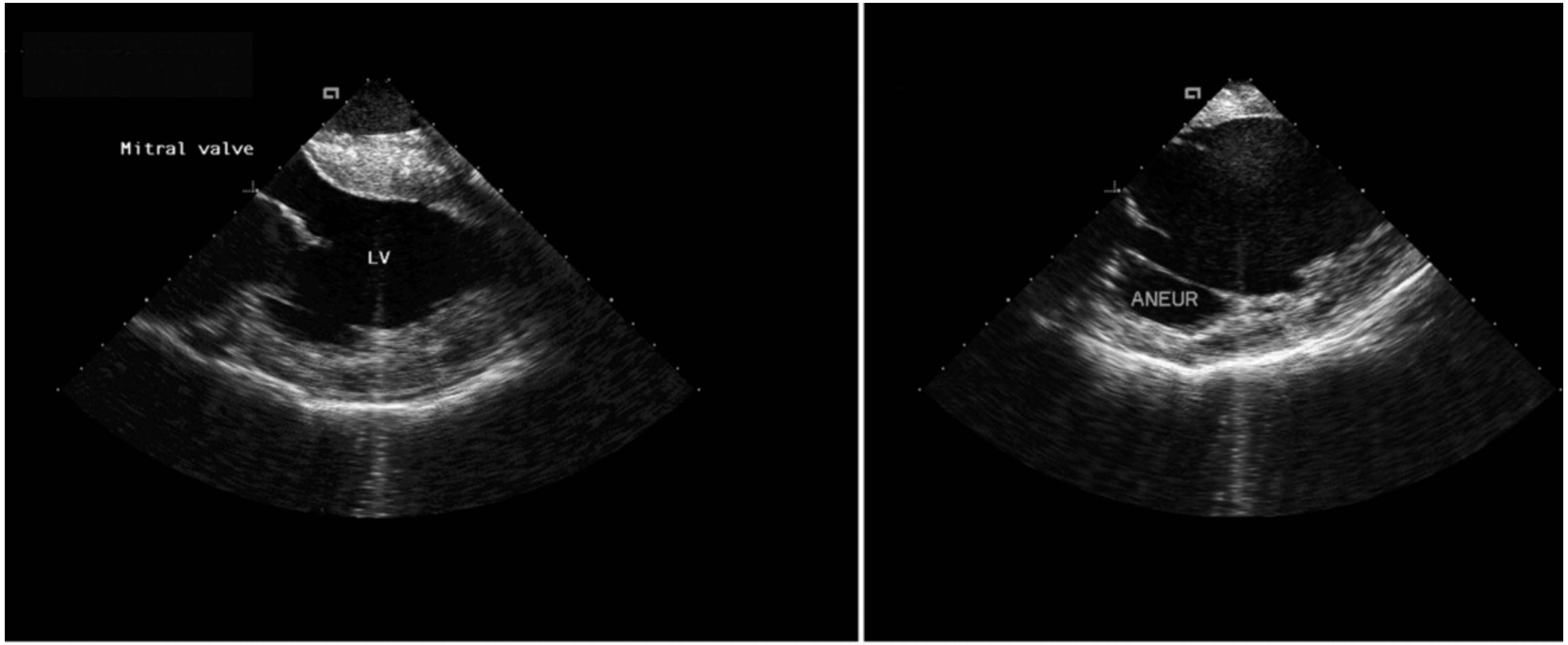
- Infarcted myocardium can be identified by wall thinning and increased echodensity of the infarcted tissue.



*Circ Arrhythm Electrophysiol. 2011 Oct;4(5):667-73.

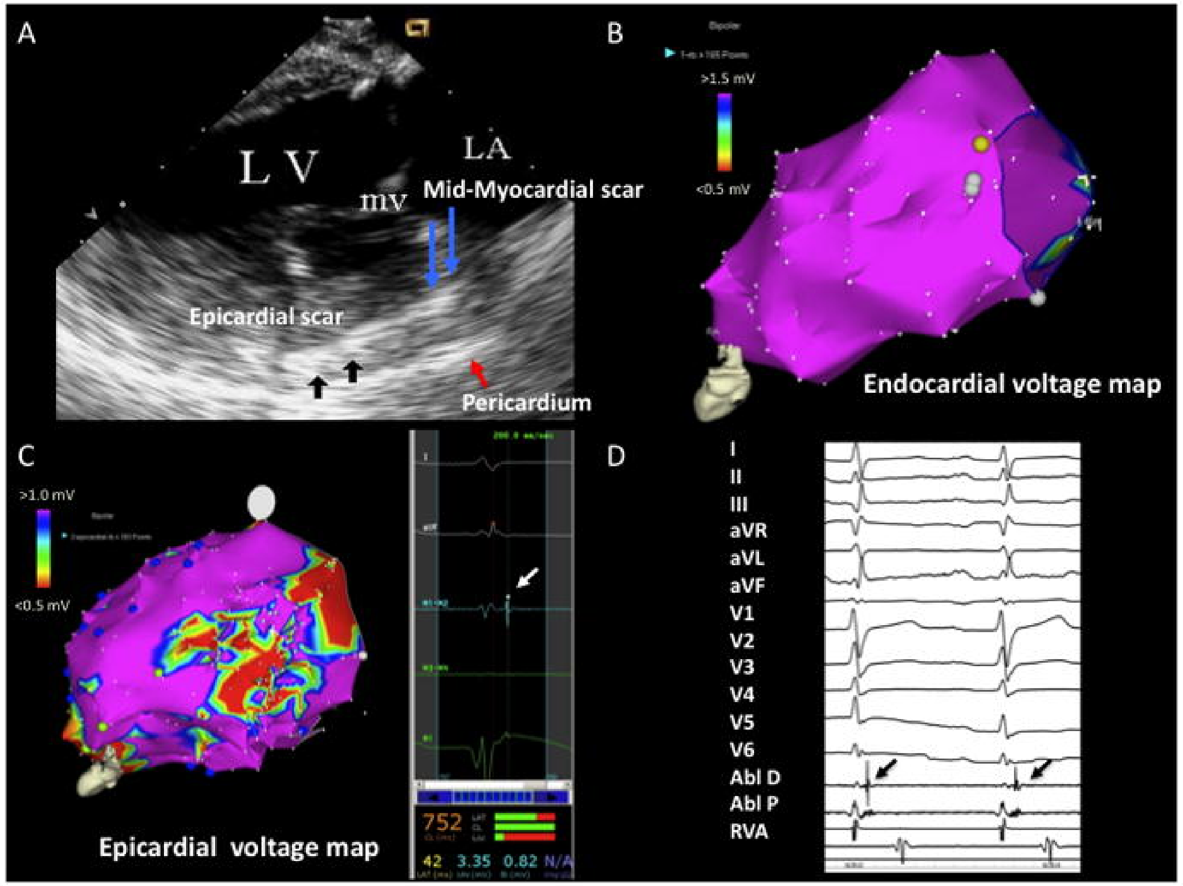


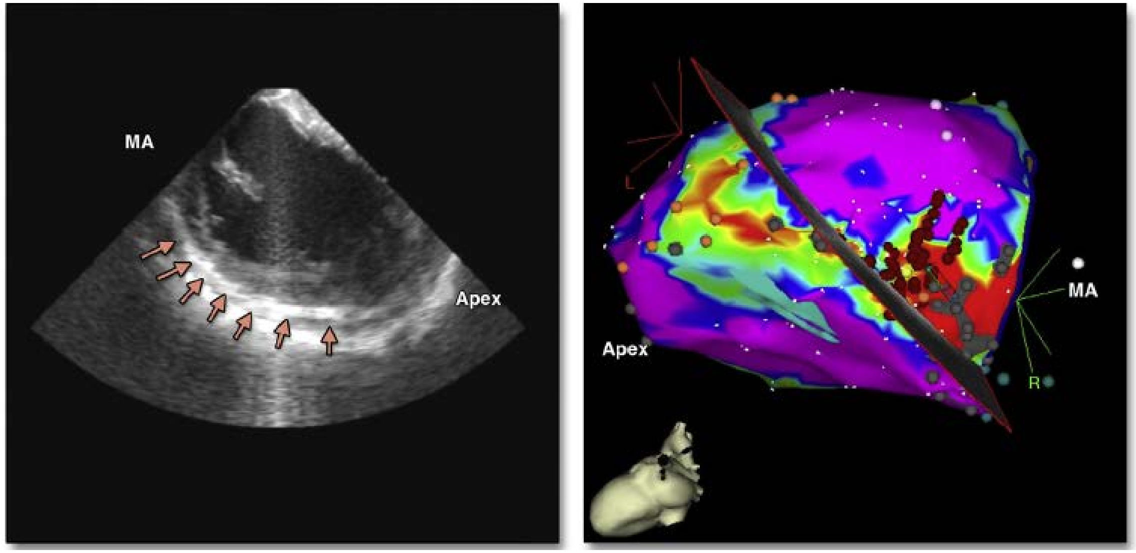
Epicardial scar



Aneurysmatic dilatation of the posterolateral LV wall

*Circ Arrhythm Electrophysiol. 2011 Oct;4(5):667-73. Eur J Echocardiogr. 2004 Jan;5(1):34-40.

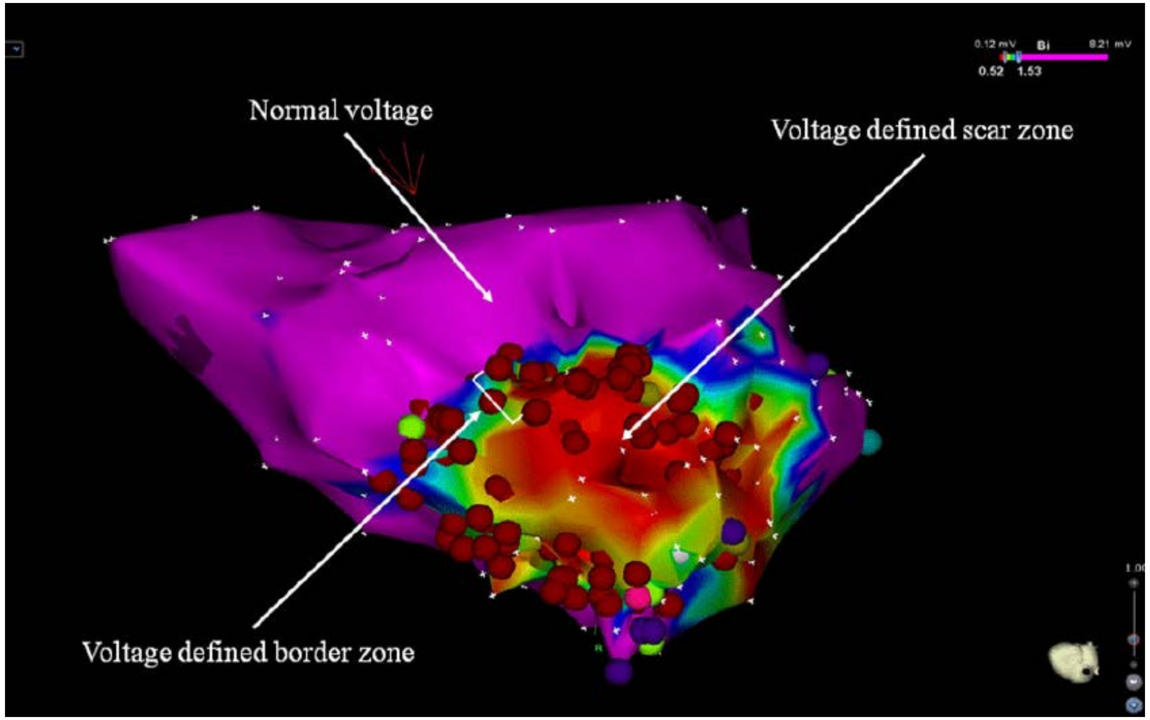




- In patients with epicardial scar tissue, an increased echodensity of epicardial tissue seen on ICE has been correlated with scarring.

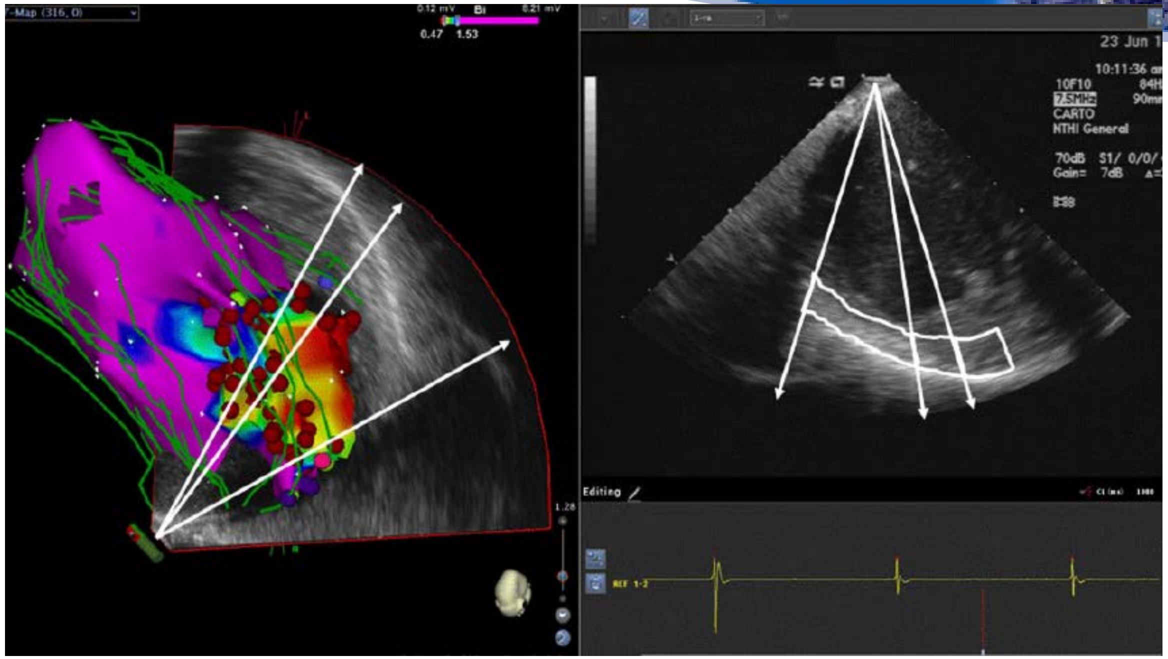
*JACC Cardiovasc Imaging. 2016 Jul;9(7):873-886. Circ Arrhythm Electrophysiol. 2011 Oct;4(5):667-73.

Quantitative Assessment of VT scar substrate by ICE



voltage-defined
- Scar zones : bipolar voltage <0.5 mV
- Border zones (0.5–1.5 mV)
- Normal myocardium (>1.5 mV)

*Pacing Clin Electrophysiol. 2014 Apr;37(4):412-21.



Side-by-side analysis of voltage maps and ICE images

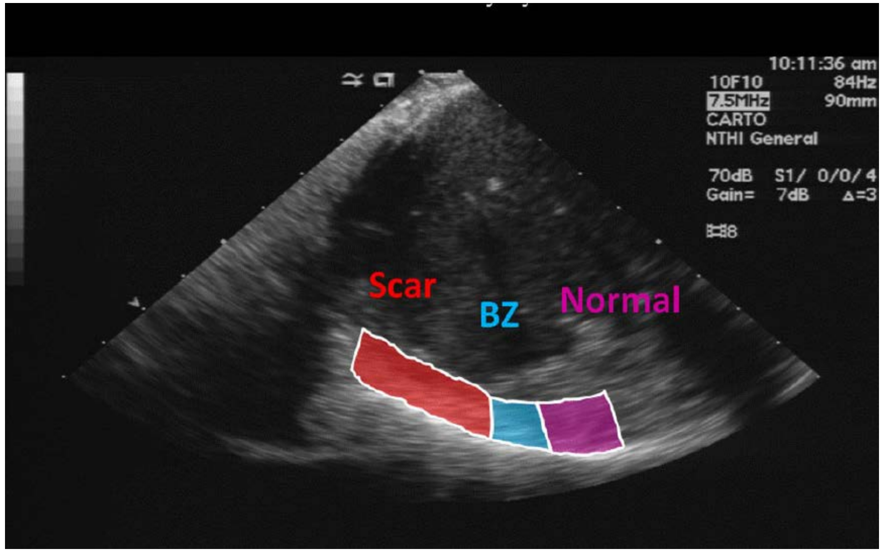
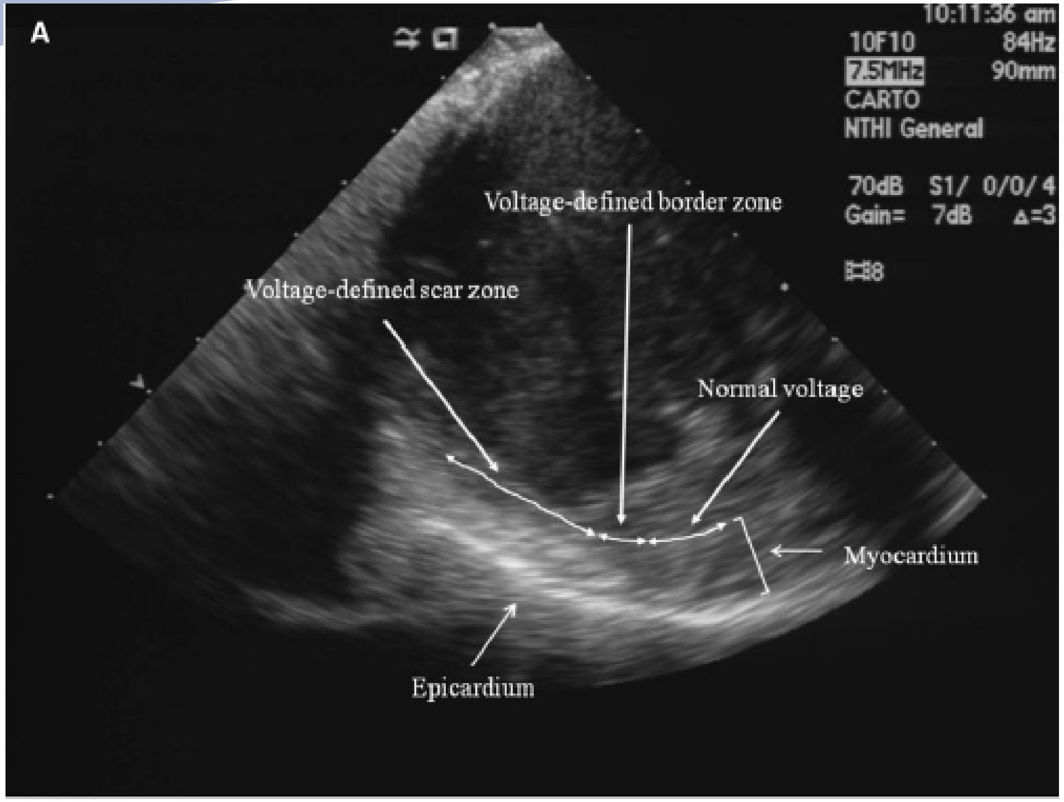
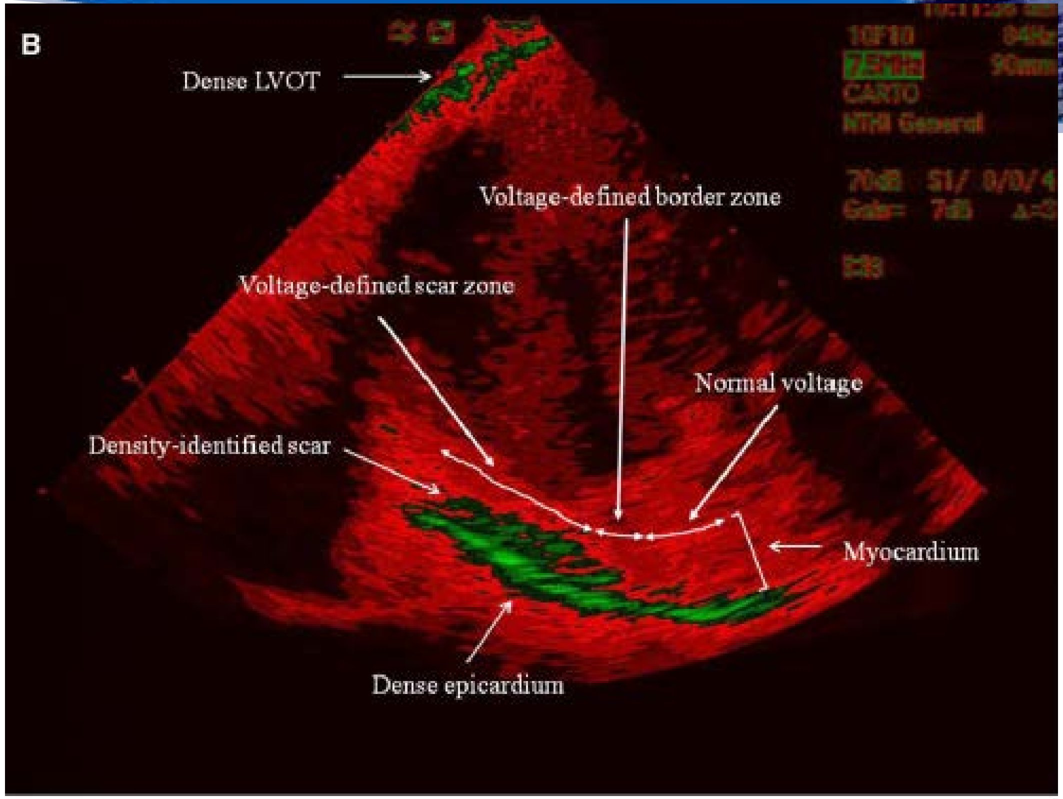
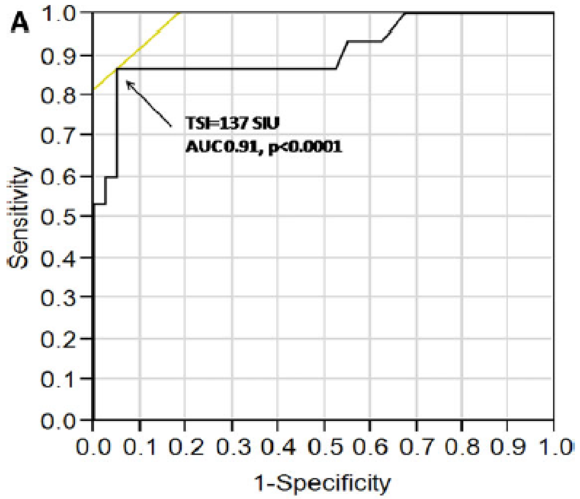


Image analyses of tissue density and heterogeneity in myocardium





Non-enhanced 2D ICE

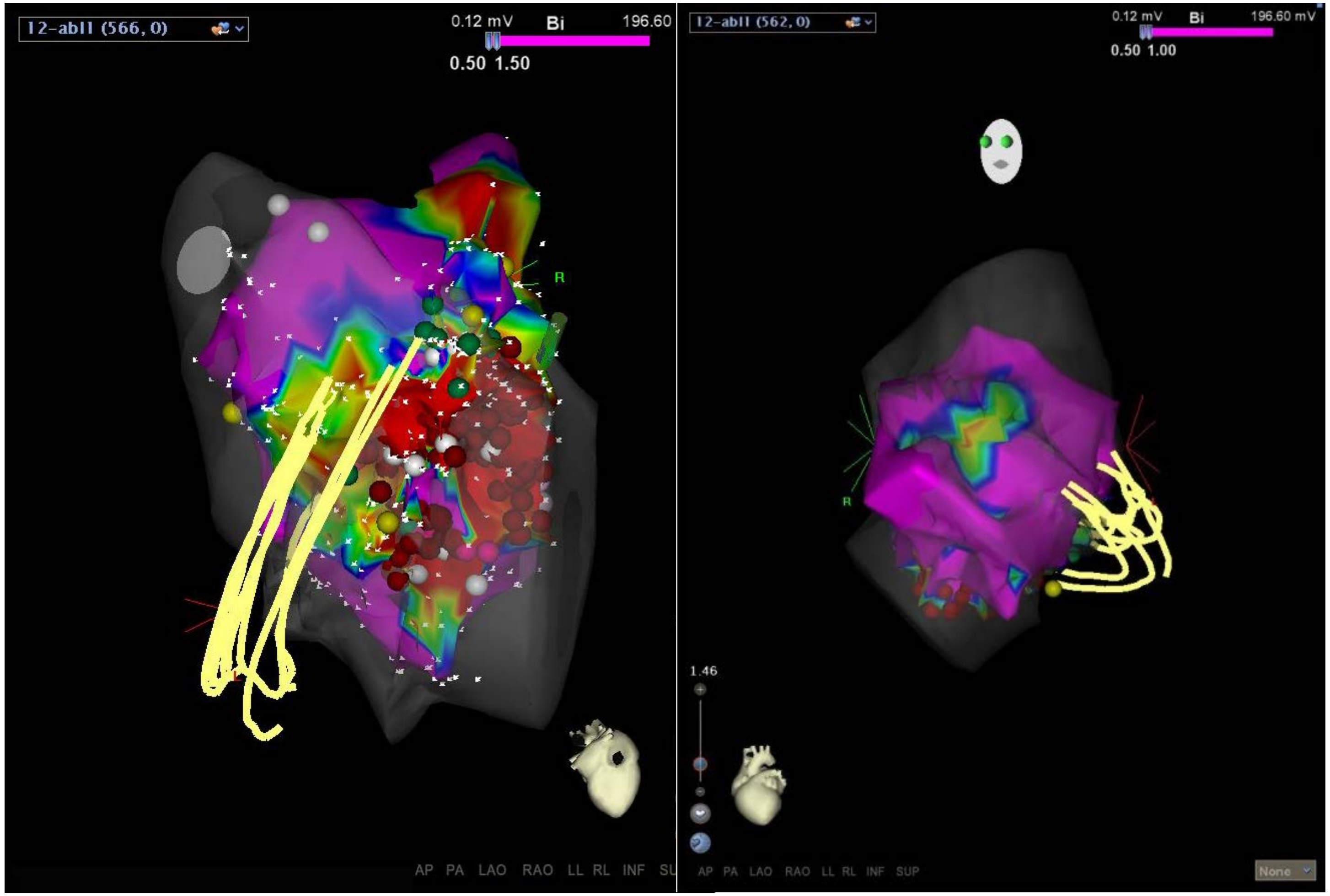


Signal intensity-based color enhanced image:

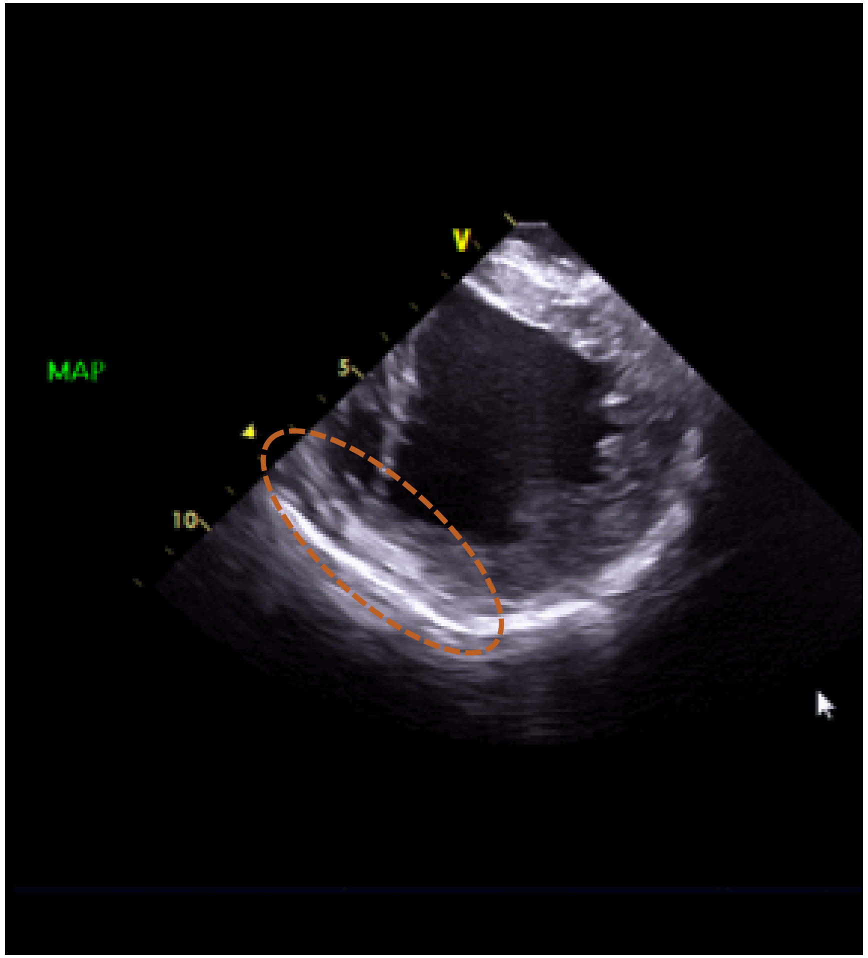
Software-based color enhancement employed to facilitate visual identification of scar zones (green, signal intensity ≥137 SIU)

*SIU = signal intensity units; gray level on 0–256 gray scale for 8-bit images

Real case: 64-year old male with scar-related VT



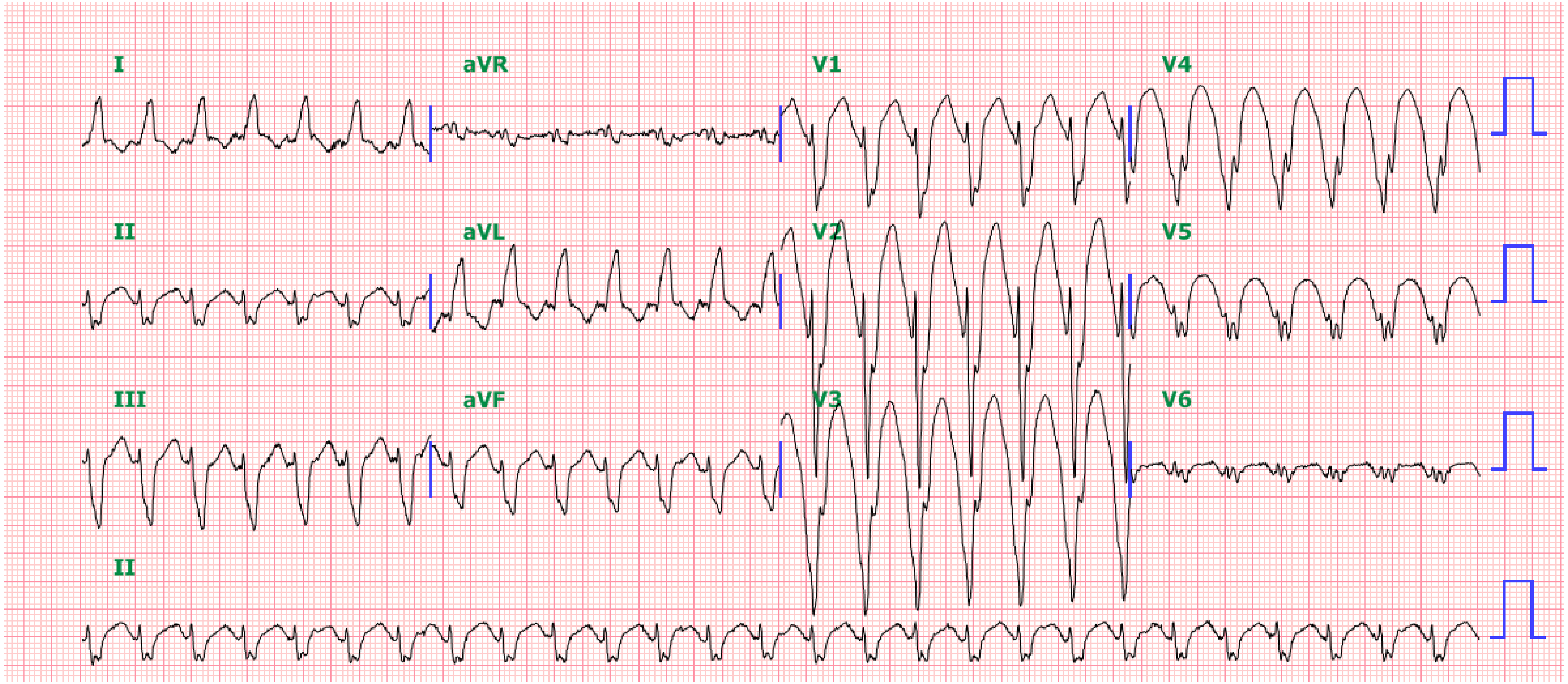
Scar area marked by yellow lines at LV posterior wall near posteromedial papillary muscle



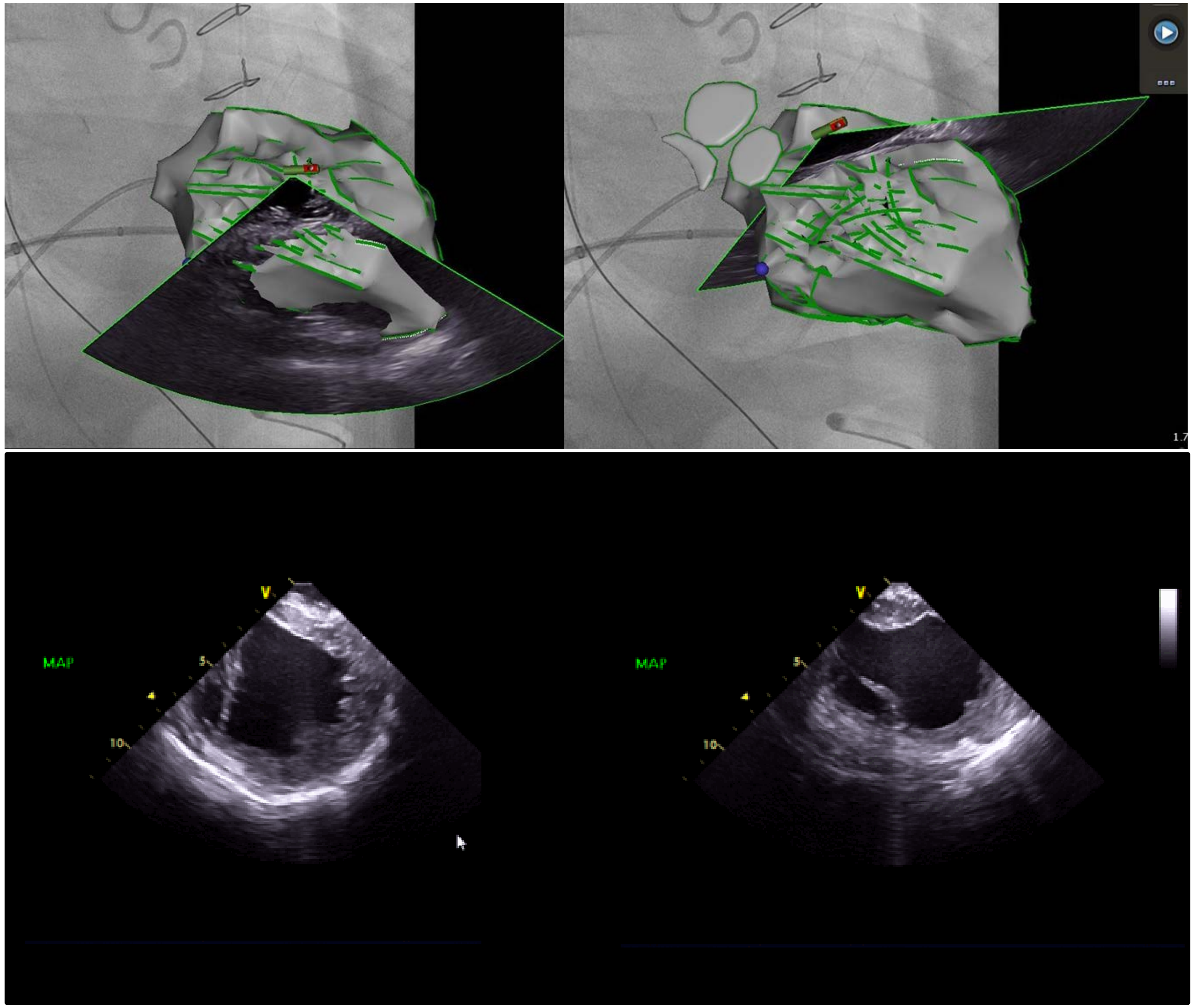
Hypokinetic LV wall with bright scar area noted by ICE

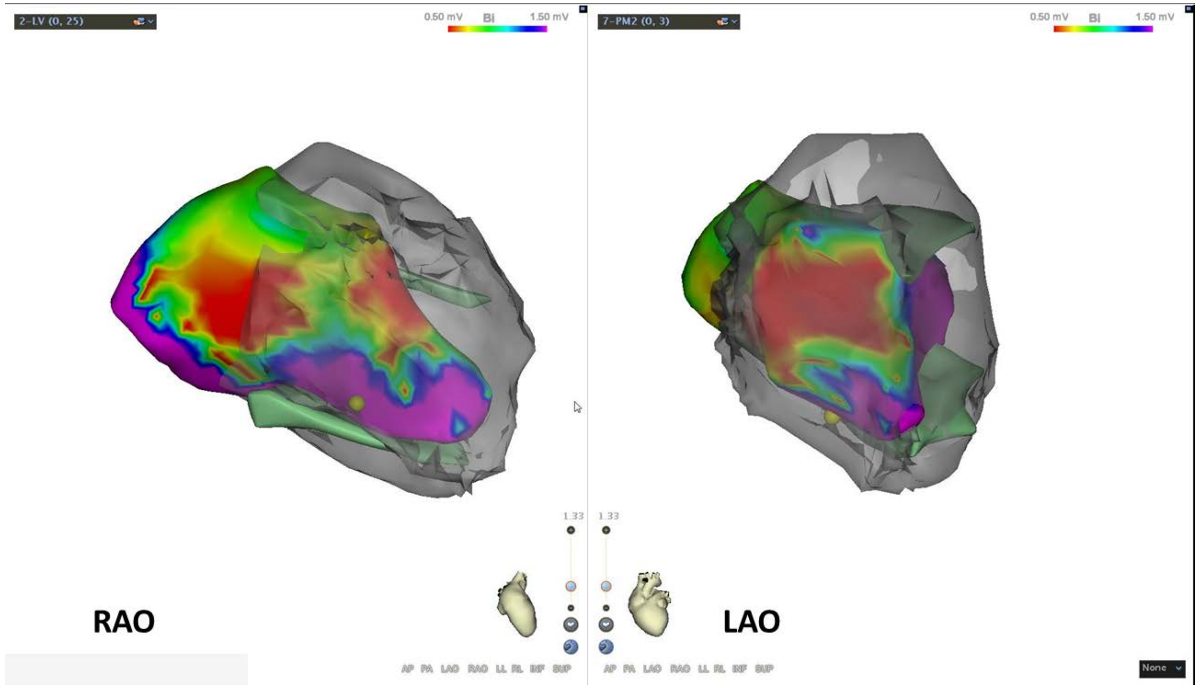
Summary case

- **70-year old male with ischemic cardiomyopathy**

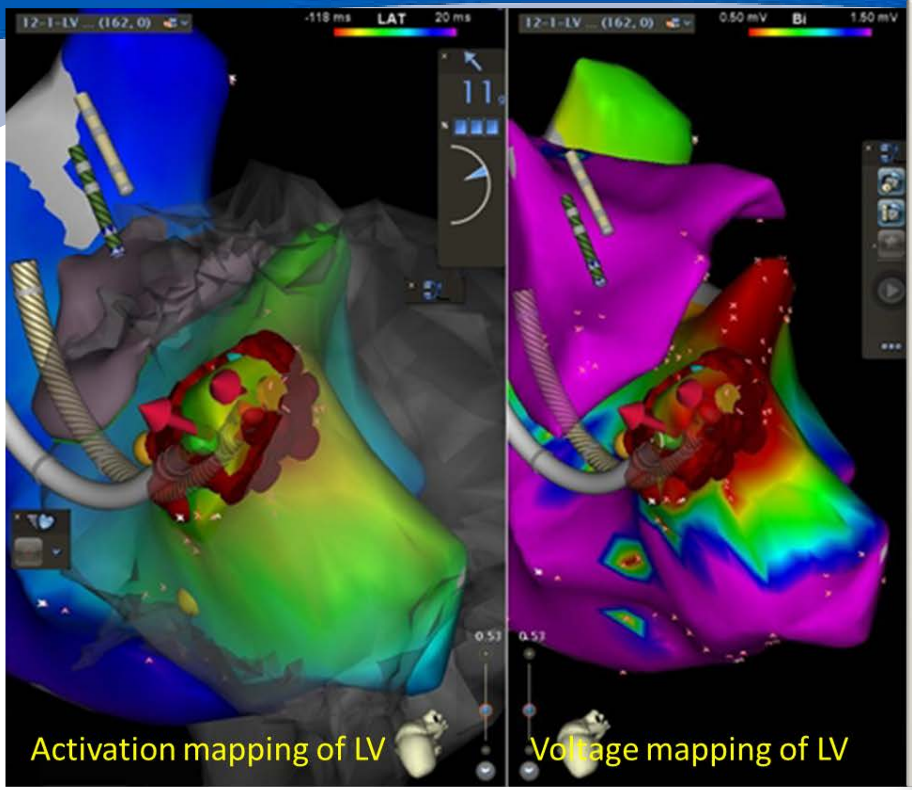


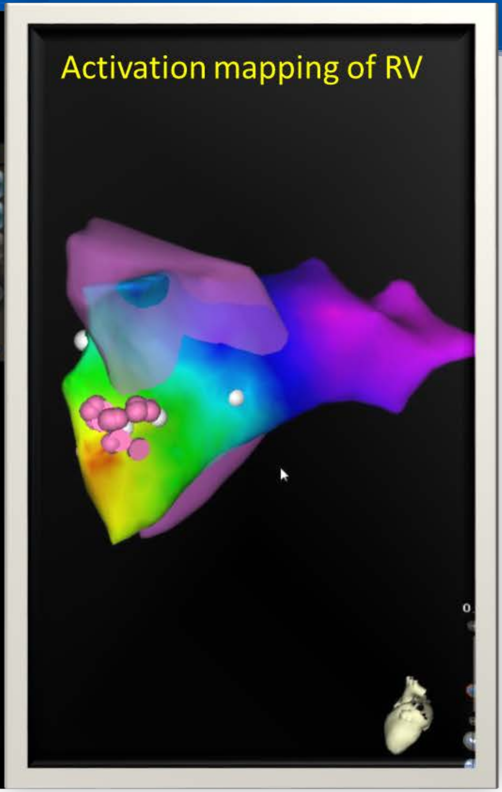
ICE-guided anatomic mapping of LV

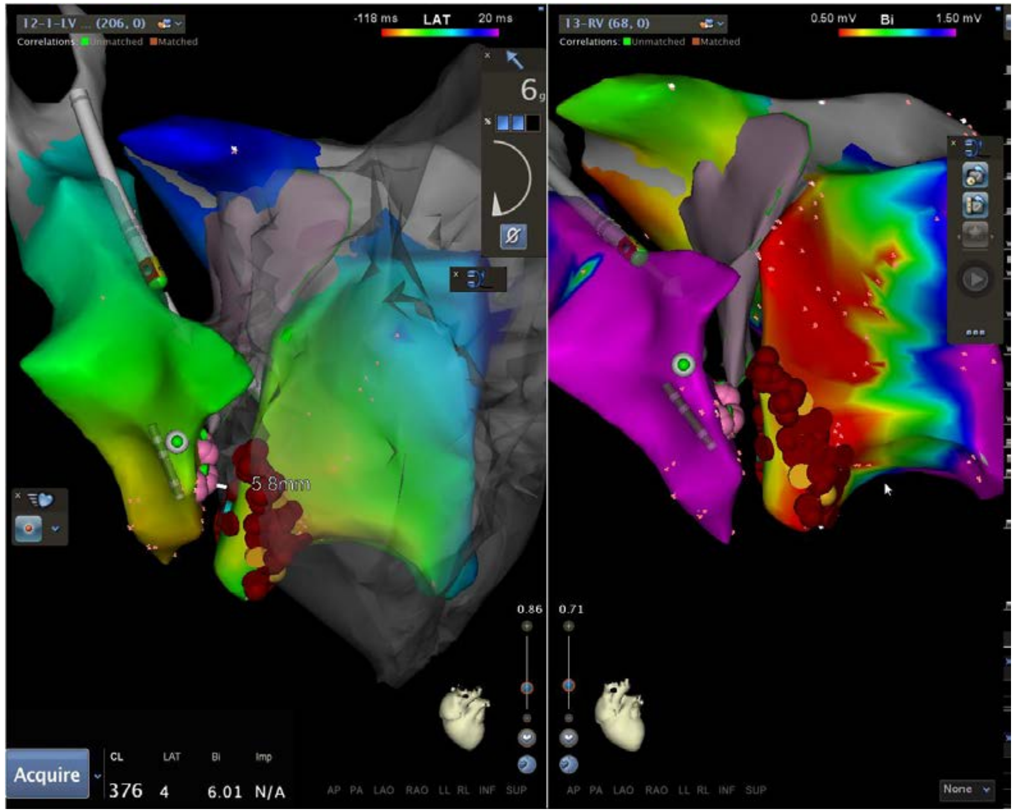




The voltage mapping showed that low voltage area was located in the septal aneurysm detected in ICE images.


-118 ms LAT 20 ms
0.50 mV Bi 1.50 mV
Activation mapping of LV
Voltage mapping of LV


Activation mapping of RV


-118 ms LAT 20 ms
0.50 mV Bi 1.50 mV
5.8mm
Acquire
CL LAT Bi Imp
376 4 6.01 N/A

Role of ICE during VT ablation

Direct visualization of anatomy, catheter, and lesion formation

Identification of substrate

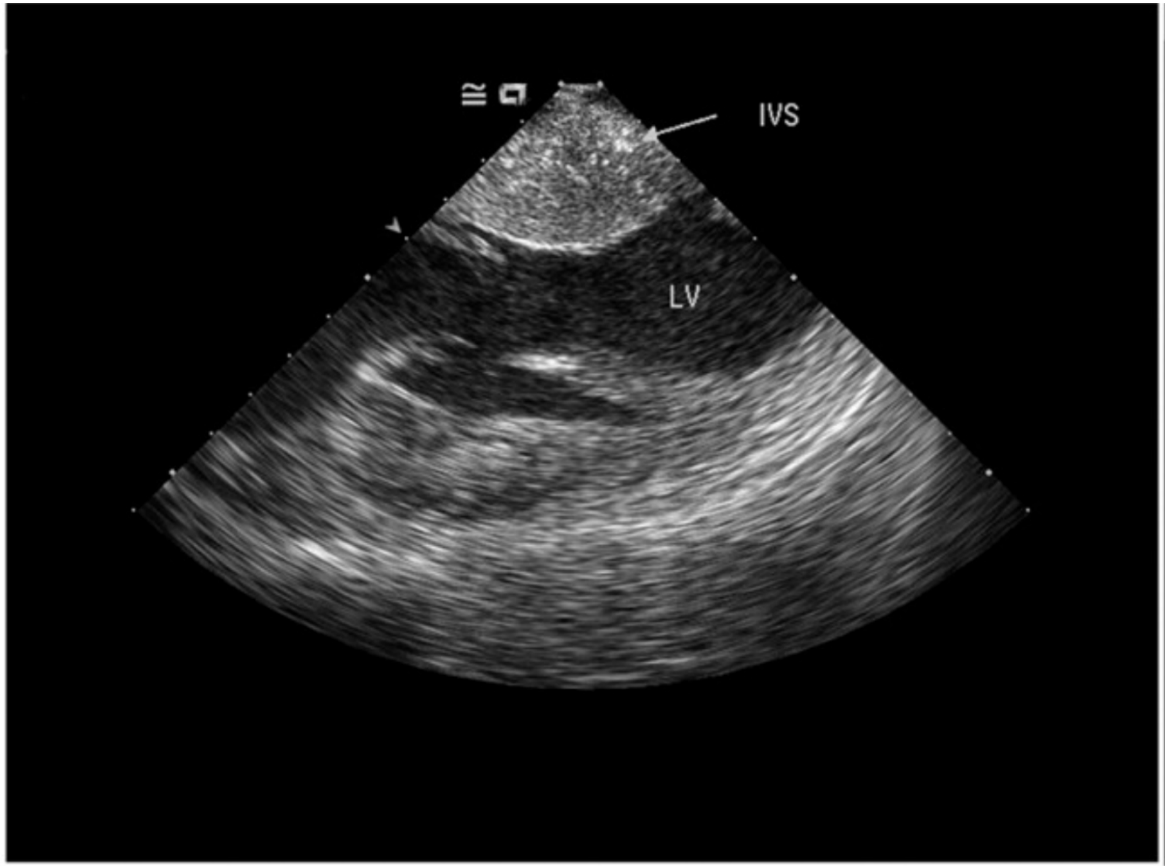
Continuous monitoring for complication

- One of the important roles of ICE imaging is in the early diagnosis and prevention of potential complications during ablation procedures.

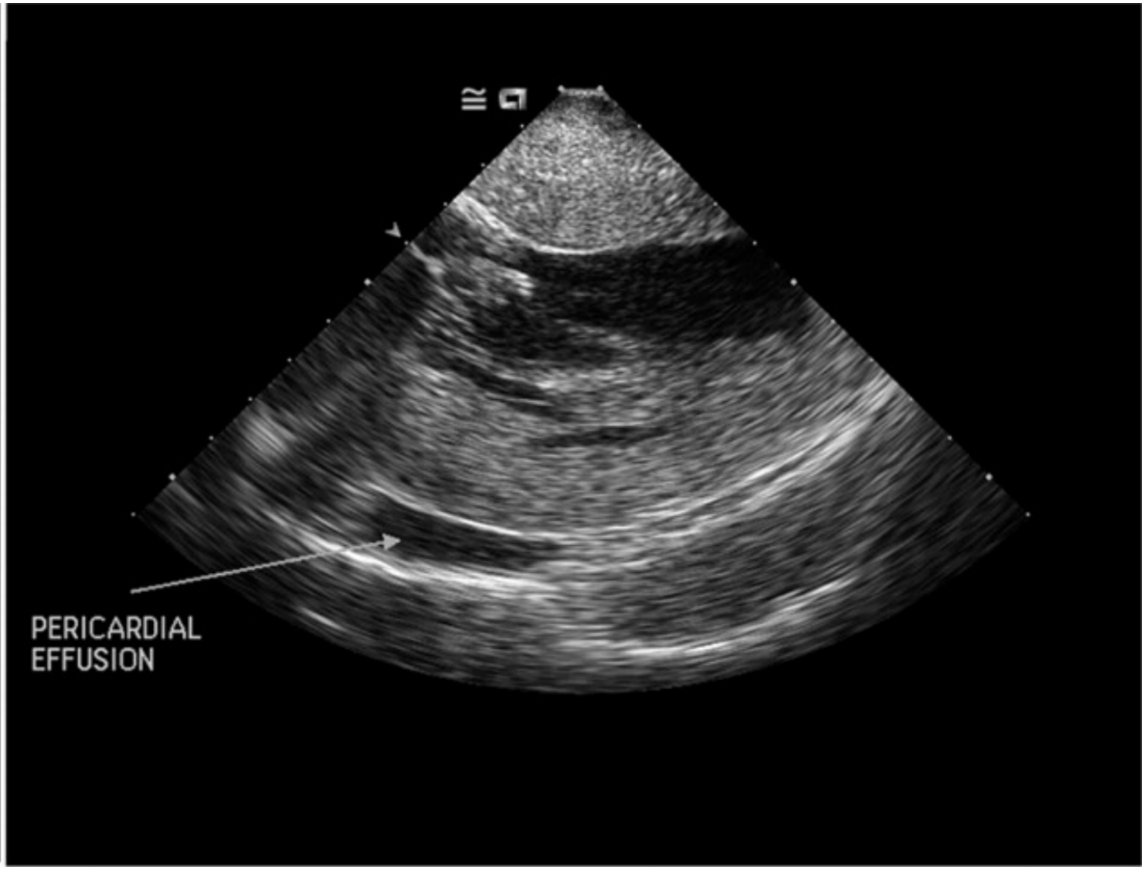
- ICE has proven an effective real-time monitoring tool to enhance early detection of pericardial effusion in transseptal catheterization.

- ICE can typically detect
  - <20 cc of pericardial fluid at baseline assessment; no echo-free space or less than 1 to 2 mm of echo-free space seen posteriorly only during systole
  - Small amount (50 to 80cc); 2-5 mm of echo-free space
  - Easy to differentiate clot from fluid; more sensitive to detect small amount of pericardial effusion with greater resolution.

*Echocardiography 2007;24:533– 400. J Am Coll Cardiol Intv 2009;2:705–17.



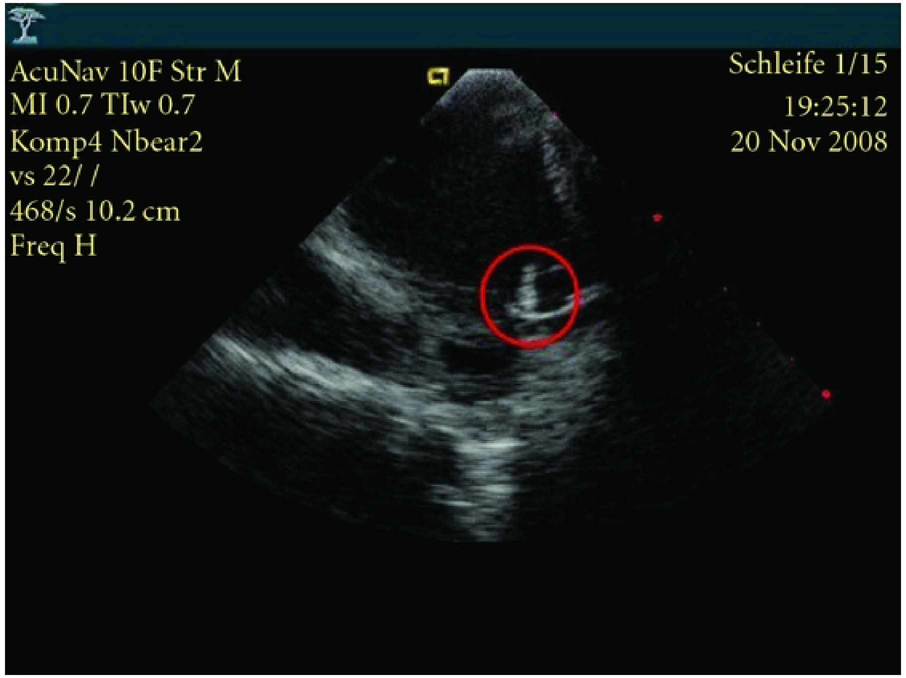
Pre-procedural small pericardial effusion



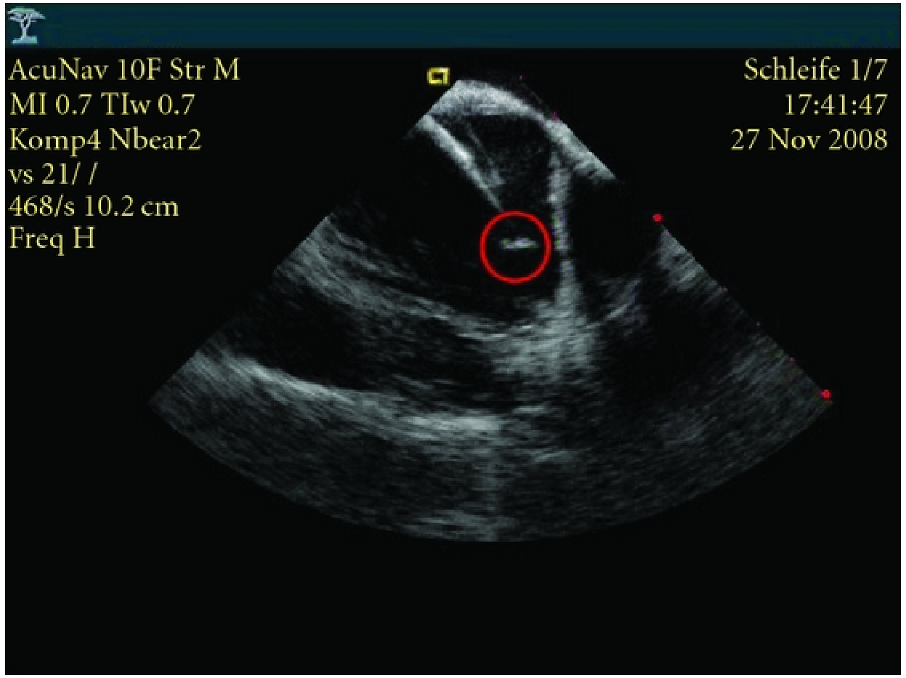
Constant quantity of effusion during procedure

*Eur J Echocardiogr. 2004 Jan;5(1):34-40.

- The short dwell time of foreign material within the slow flow area of the left atrium is sufficient for thrombus formation.
- The thrombi are usually single, linear, and mobile, and are typically attached to a catheter or sheath.

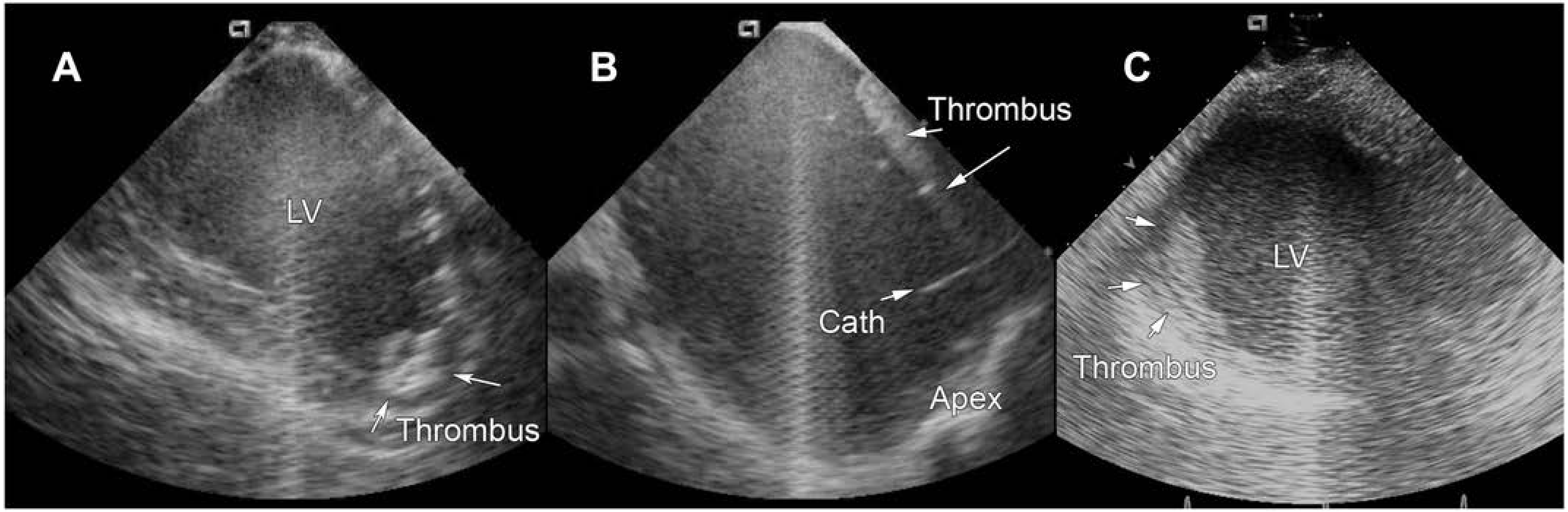


Thrombus attached to the circular mapping catheter



Thrombus attached to the tip of transseptal sheath

*Echocardiography 2007;24:533– 400. Cardiol Res Pract. 2011; 2011: 615087.

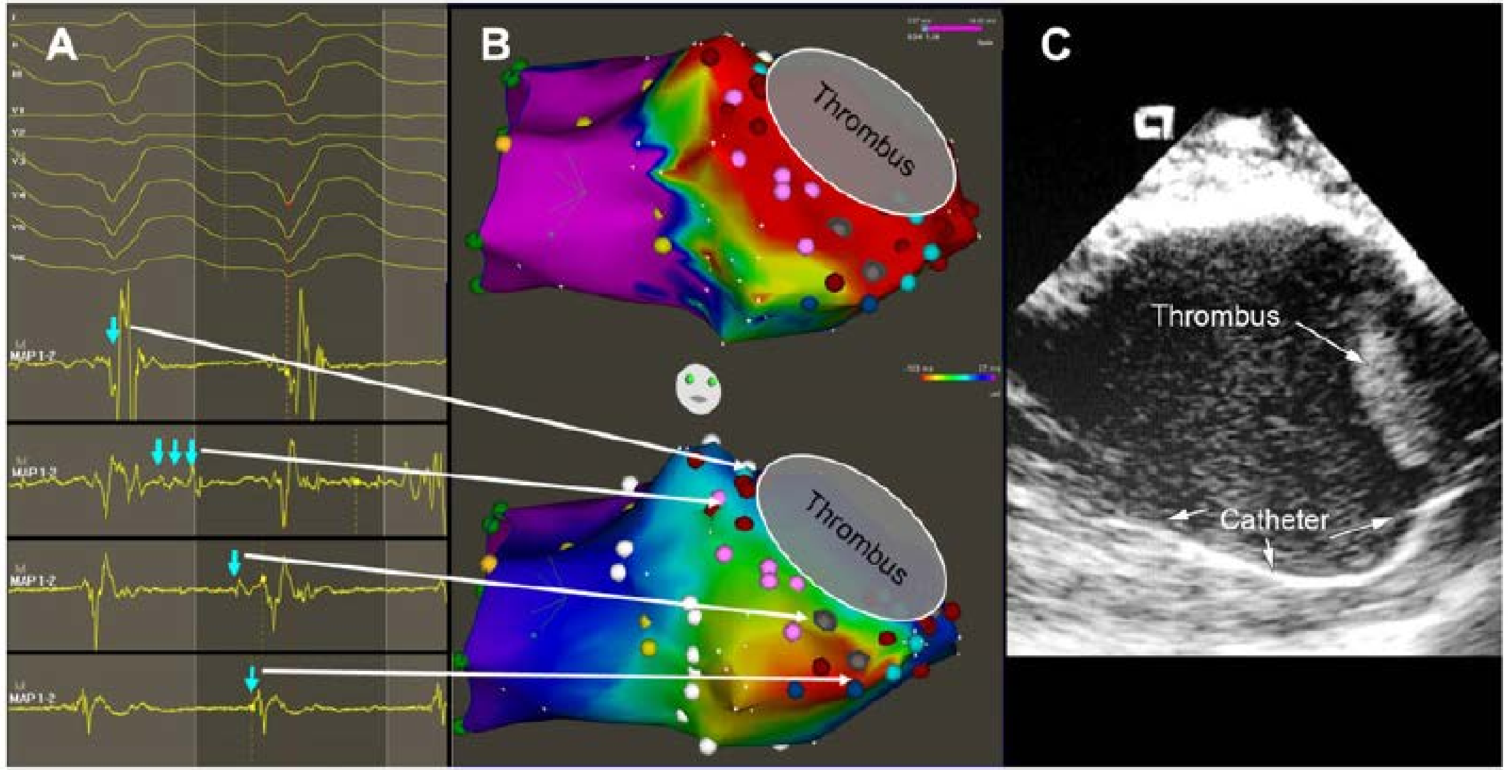


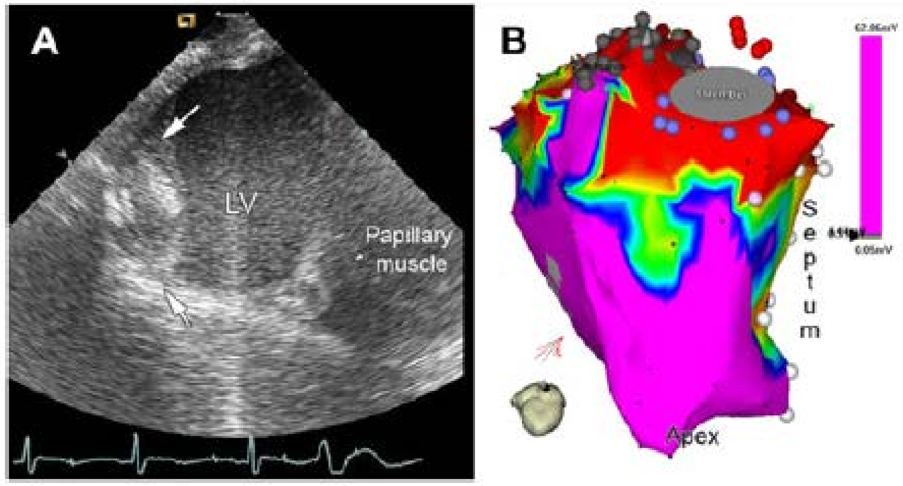
Small apical thrombus

Thin-layered mural thrombus at the septum

Small mural thrombus in the aneurysm

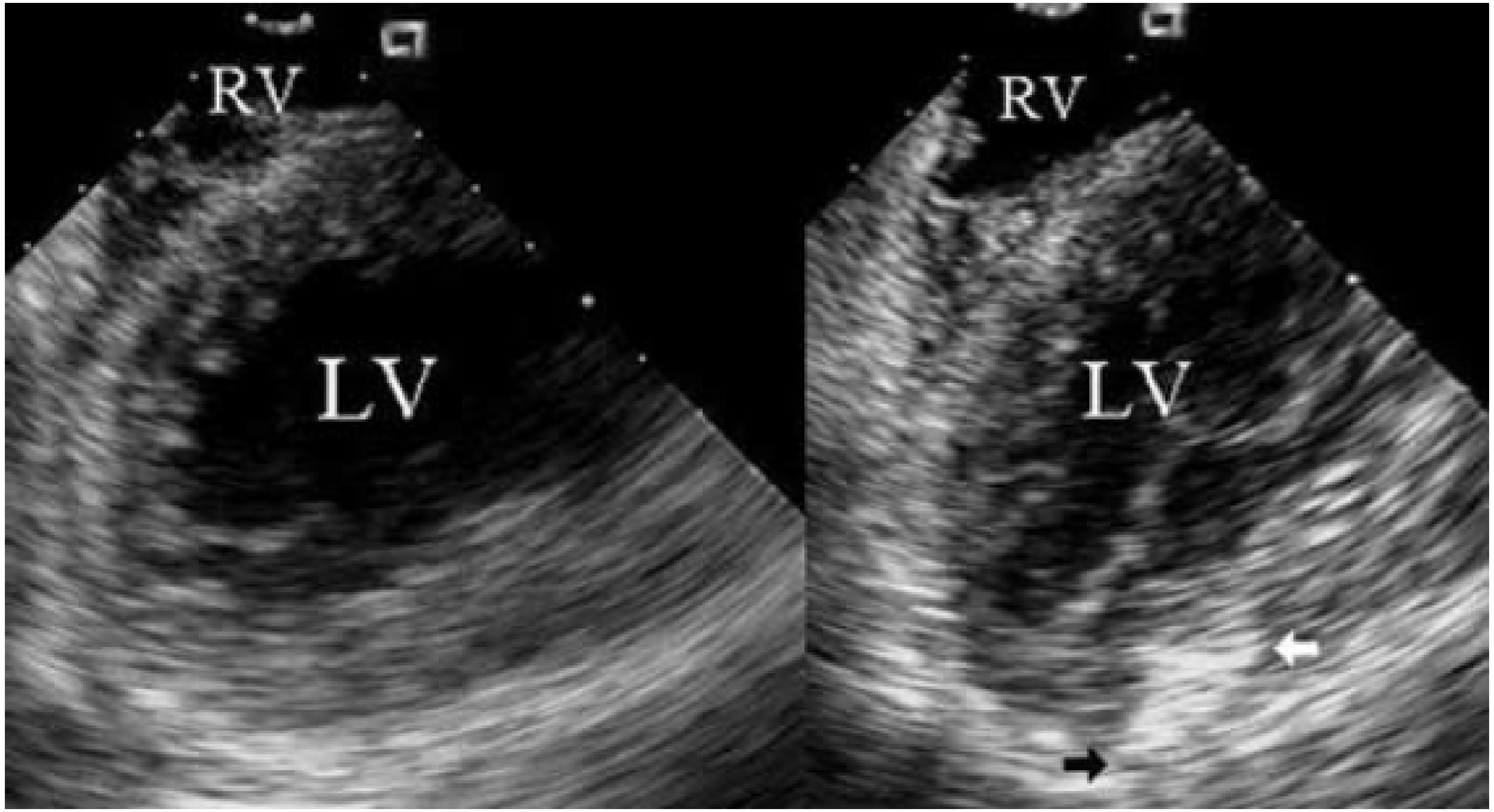
*Pacing Clin Electrophysiol. 2016 Jun;39(6):581-7.





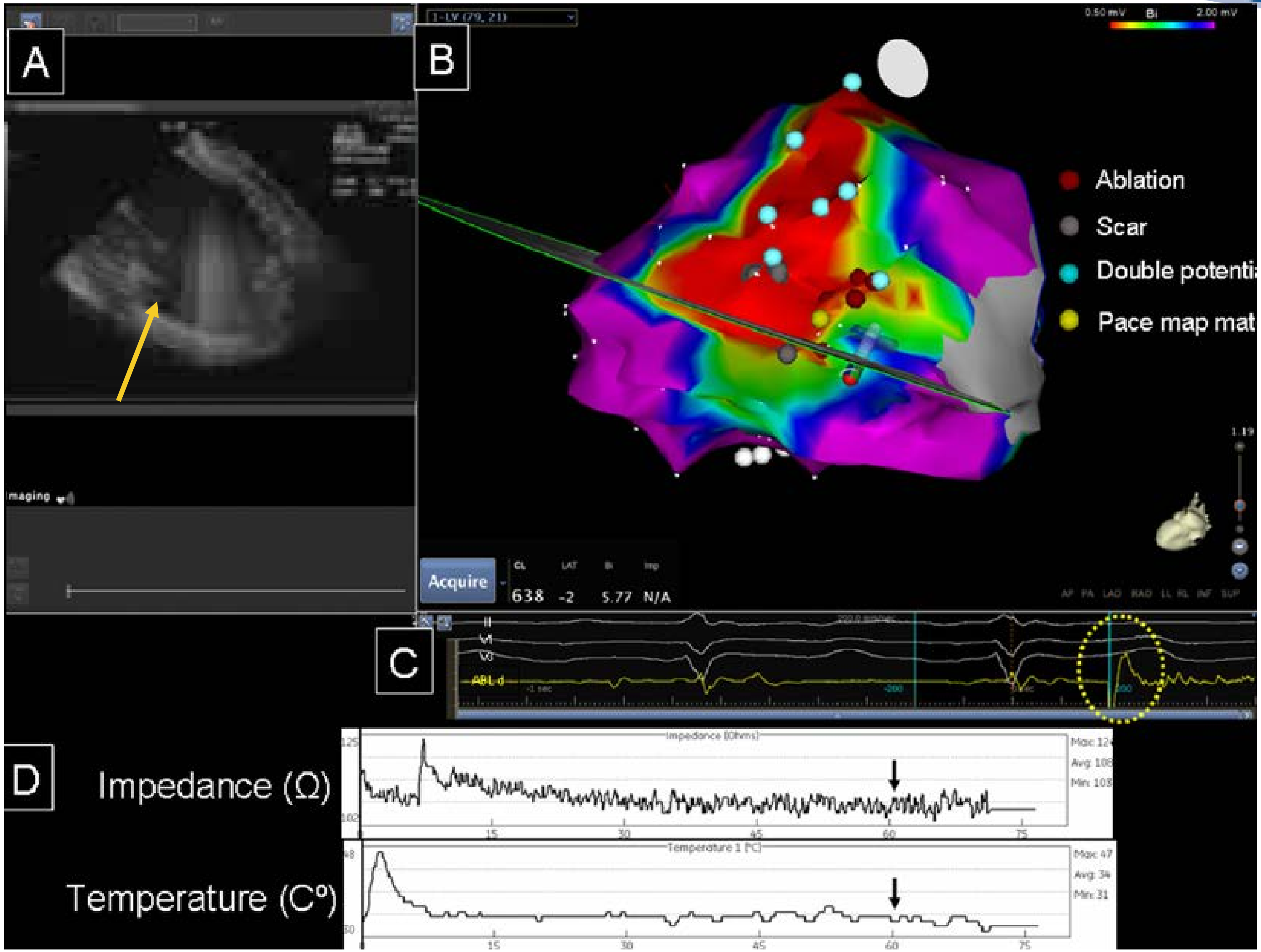
Patient	LVEF (%)	Aneurysm Location	History of Bypass Surgery	Interval between Ablation and MI (Months)	Clinical VT CL (ms)	Thrombus Detected by TTE	Size of Thrombus (mm)	Number of Ablation Procedures	Epicardial Ablation	Outcome
1.	25–30	Anterior	Yes	336	428	No	12 × 18	5	No	No recurrence
2.	30–35	Anterior	Yes	372	350	Yes	10 × 31	1	No	Two VT episodes treated with ATP
3.	35	Anterior	No	132	500	Yes	11 × 24	2	No	No recurrence
4.	25–30	Inferior	No	N/A	521	No	16 × 30	2	Yes	Single VT episodes treated with ATP
5.	25–30	Anterior	Yes	216	272	Yes	16 × 18	2	No	Implantation of VAD
6.	40	Anterior	No	288	500	No	12 × 21	3	Yes	No recurrence
7.	20	Anterior	No	66	400	Yes	6 × 33	3	Twice	Died
8.	35–40	Inferior	No	240	461	No	7 × 27	1	No	No recurrence

*Pacing Clin Electrophysiol. 2016 Jun;39(6):581-7.



Before coronary angiography | **After coronary angiography**

*Echocardiography. 2007 May;24(5):533-40.



*Heart Rhythm. 2013 Oct;10(10):1558-9.

Summary

- The recent advance of the real time ICE with Doppler capabilities and integration into the 3D mapping system provides the ability to directly image cardiac anatomy and intracardiac events during various procedures.

Identification of substrate

- ICE is feasible in guiding VT ablation. The use of ICE in adjunction with fluoroscopy and mapping procedures will facilitate treatment of VT and may contribute to the safety of the procedure.

Continuous monitoring for complication

Thank you