VT management in LVAD Pts

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Financial Disclosure

- Consultant for Abbott
- Consultant for Johnson & Johnson

Topics of presentation

- Introductions (LVAD experiences: what we learned)
- ICD in LVAD pts
- UVH LVAD VT ablation experience
- Clinical observations from ablation procedure
- summary

LVAD Survival

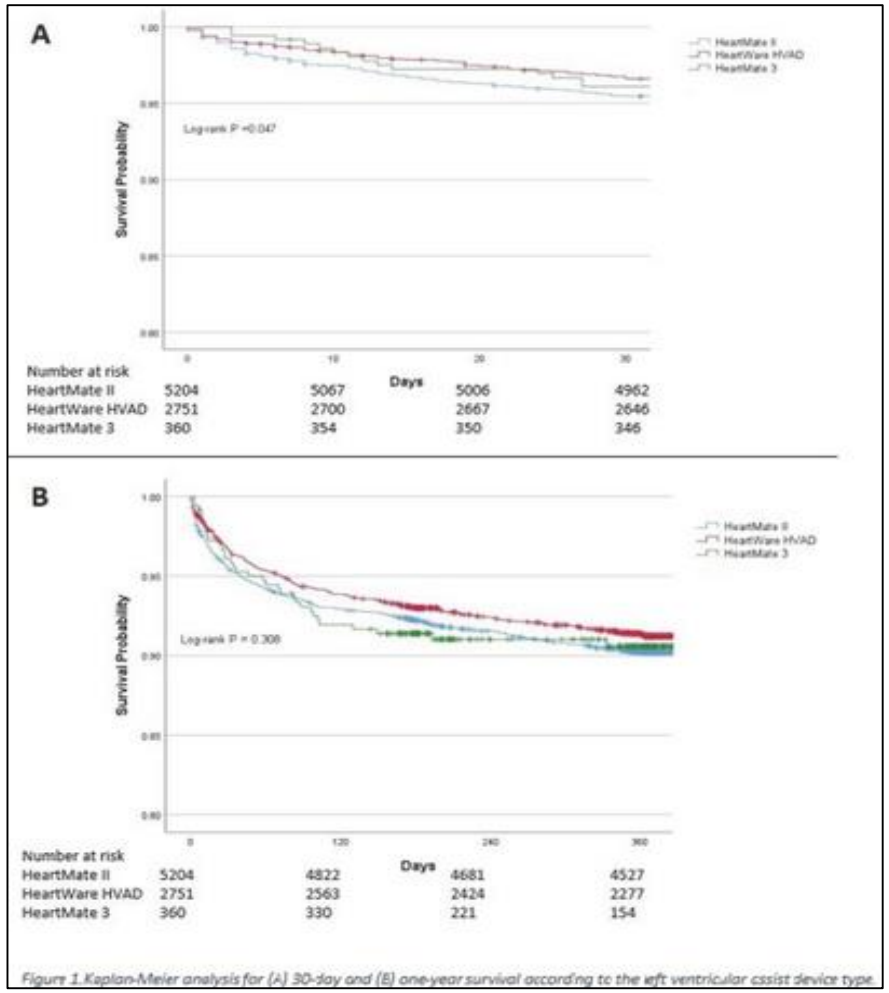


Figure 1 Kaplan-Meier analysis for (A) 30-day and (B) one-year survival according to the left ventricular assist device type.

Exponential growth of LVAD implant in US since 2016
Significant number of pts are for destination therapy and continues to grow

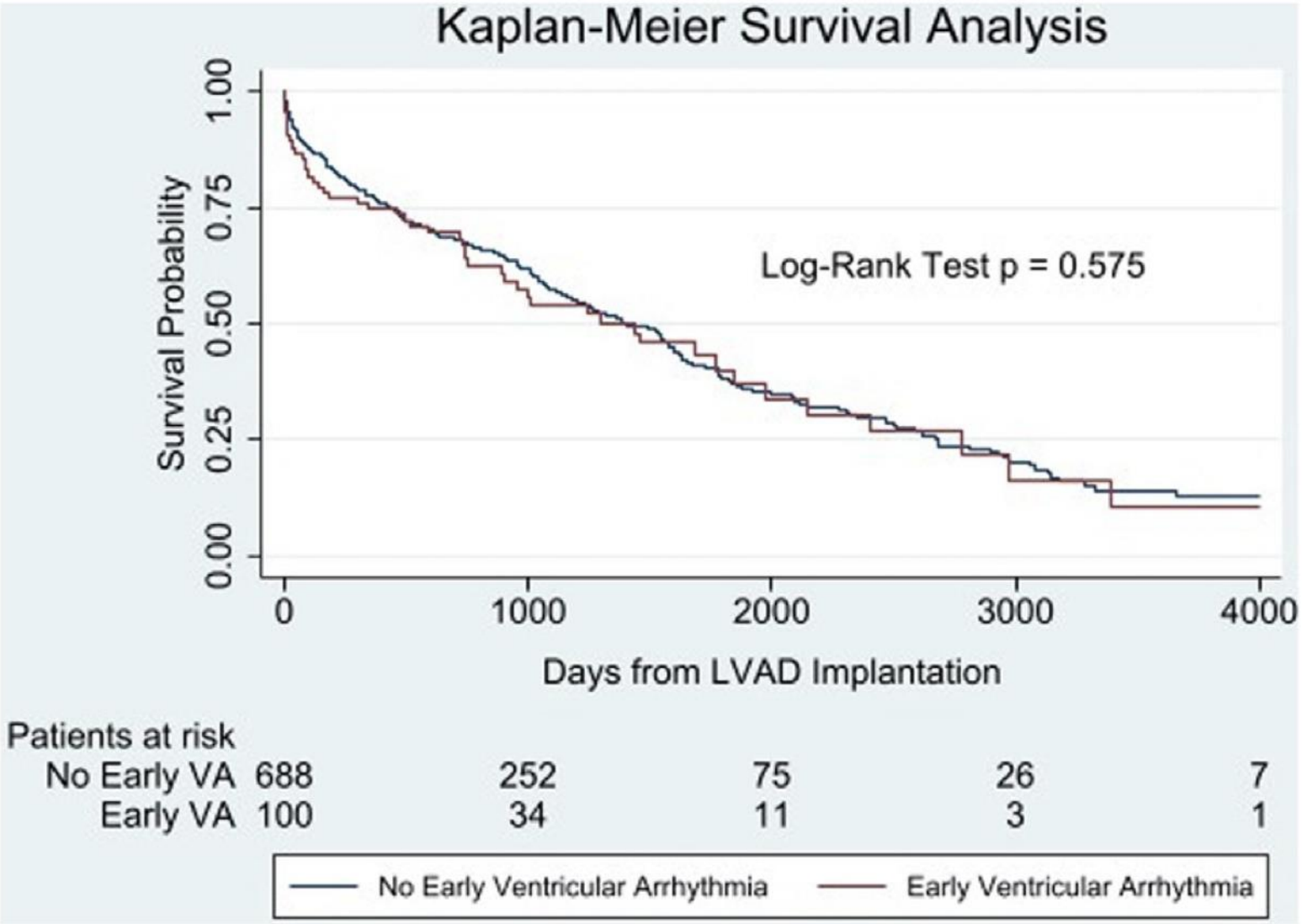
Factors that improved survival:
1) surgical tech and experiences
2) LVAD technologies
3) Management of Complications:
   GI bleeding, pump thrombosis, stroke, RV failure, infection, hemolysis, and arrhythmia (VT , Afib)

Osama Mahmoud et al. *J Am Coll Cardiol* 2021; 77:752-752.

Cardiac arrhythmia and LVAD outcomes

- Early ventricular arrhythmia occur in 20 to 28% of patients undergoing LVAD implant and increases 1-year post LVAD mortality.
- VT within 30 days post-LVAD is associated with worse outcomes
- The short-term mortality after VT storm is high, and more than 20% of death within 15 days.
- AF is prevalent in half of LVAD patients with recurrent VT, but is also in independent predictor of recurrent VT.
- Other risk factors are: pre-implant History of VT, ICD shocks, anti-arrhythmic drug therapy and Right ventricular failure (RVF)
- Significant short term improvement of survival in VT ablation group vs medical therapy

Early data: VT in LVAD and Long term outcome



1) Post LVAD 13% pts had had early VA
2) Long term follow-up showed no significant difference
3) Can Ablation of VA improves outcomes ?

ICD and LVAD

- Pre-LVAD device implant , 38% pts had device, (Bi-V 26%)
- ICD therapy is common (1/3 pts) in the first year after LVAD implantation;
- Ventricular arrhythmias are highly clustered in this cohort;
- ATP is effective. ICD programming: aggressive ATP with longer and higher numbers of therapies: VF zone > 240bpm.
- Routine systematic evaluation and re-programing of ICD including **DFT, RV sensing threshold testing for EMI** and need for BI-V upgrade post LVAD implant. (1 to 2 weeks post implant)
- Continuous flow LVADs have highest EMI/ICD interaction (pre-existing RV defib lead in apex, new RV sensing lead to moved to mid-septum)
- High DFT Pts: consider adding subclavian lead (if single coil) or reposition defib lead to more septal position

General guideline of LVAD VT Management

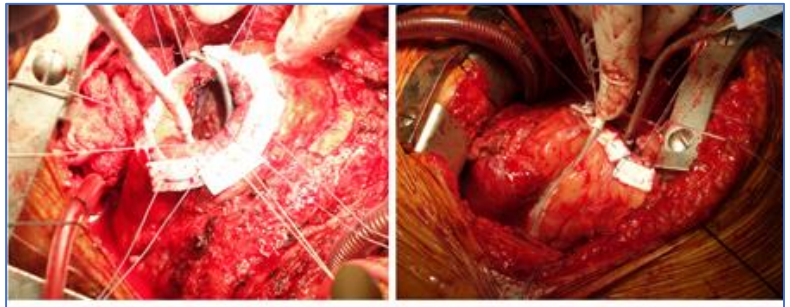
- Medical therapy: HF management is first line of management to stabilize the pt and evaluation for ablation. (HF, LVAD pump adjustment, new ischemia)
- Surgical ablation with/without MAZE during LVAD implant: pre-LVAD refractory VT. (Recurrent VT or previously failed ablation and Afib)
- Ablation post LVAD implant:

    Catheter based ablation: RF ablation: **via trans-septal, cardiac vein,** trans-aortic and ETOH ablation

    Non-catheter based: Non-invasive radiotherapy

    Surgical ablation (RF via pericardial window and Cryo via open chest)

Surgical VT ablation during LVAD implant



- Combined LVAD implant and VT ablation is safe.
- No significant complications observed.
- Studies reported success rate close to 60%
- Pre-procedure 3-D mapping is essential to guide ablation to critical area and reduce pump time.
- Cryo surgical ablation uses endo and epicardial approach during LVAD imlant or post implant epicardial.

Reported Complications:
Massive myocardial edema and inflow cannula obstruction (ablation close to the cannula)

Refractory hypoxemia from intracardiac shunting (long pump time)

Why catheter based VT ablation for post - LVAD

- VT-free survival was significantly higher following ablation vs. medical therapy (50% vs 15%).
- Catheter ablation is more effective control for VT recurrence.
- Less invasive, therefore lower risk for complications and better tolerated than surgical ablation

UVH LVAD experience (2013 -2021: 94 pts)

- Total number pts: 15, male: 11, median age: 68 yrs
- Indication for LVAD: Bridge to transplant: 7, destination therapy: 8
- 13 pts underwent RF based catheter ablation. 2pts surgical ablations: 1pt LVAD + surgical VT ablation (cryo) and 1 pt had also MAZE with appendectomy.
- 9/13 pts underwent VT ablation in last 4 yrs
- Etiology of CM: ischemic: CM 6, non-ischemic CM: 7 (COVID CM -2), Sarcoid: 1 and non-compaction LV CM: 1
- Device pre-LVAD: 7 pts (Biv ICD - 4, ICD-2, PM - 1)
- 1 pt – prior ASD closure device

Ablation Protocol

- Indication: **VT storm, recurrent ICD therapies, persistent drug refractory VT** and frequent NS-VT with HF exacerbation. (frequent PVC excluded)
- Evaluation: Join effort from EP, transplant/HF, cardiac surgery and critical care team.
- Facility: Hybrid EP Lab set-up for electric and EMI control.
- General anesthesia.
- EP, labs staff including LVAD nurse and anesthesia (team of pre-trained staff for LVAD VT ablation protocol)
- Pre-procedure consultation for co-morbidity (renal and DM)

Ablation technique

- 4 femoral vein accesses in 12 pts, 1 pt had additional right femoral artery access. (His/RV, CS, ICE and trans-septal)
- Trans-septal approach using deflectable sheath with deca-polar mapping catheter in 4pts, Penta-ray catheter in 1pt and HD Grid catheter in 8 pts
- Ablation was performed using contact sensor open irrigation catheter in 9 pts and irrigation ablation 4 pts.
- Trans-aortic approach in 1 pt with ASD closure device
- All pts had ICE catheter monitoring during procedure for LV volume assessment, aortic valve opening including regurgitation and RV failure.

VT mechanisms

- 37 sustained VTs were observed or induced
- Macro reentry VT from both ventricle from pre-existing substrate (87%)
- Focal, Micro-reentrant or transmural reentry ? (10%)
- Bundle branch reentry (3%).
- 3 pts developed polymorphic VT and VF (early recurrences) with trigger PVC: 1 pt- new embolic ischemia, 1 pt - high speed turbine RPM. (High turbine RPM LV septal extrusion with RV compression) and 1pt - mechanical irritation from inflow cannula.

Endocardial catheter ablation: Result

- Acute success with elimination of clinical VT (4/13 pts) and elimination of all induced VT (5/13 pts).
- Suspected VT origin from deep myocardium or epicardial focus were the main cause of endocardial ablation failure (4/13 pts) including non-ischemic (COVID) and sarcoid.
- LV lateral wall VT ablation with direct cannulation of postero-lateral cardiac vein with ablation catheter for bipolar ablation (1 pt), radio-ablation (1 pt non-ischemic lateral wall VT) and Surgical window access or surgical epicardial ablation (2 pts).
- 2 pts deceased within 48 hrs post procedure (1 pt:GI/DIC bleeding, 1 pt: with Non LV compaction CM from thrombo-embolic stroke), 1 pt deceased within 100 days post procedure (out of hospital care facility) possibly from sepsis (no CT/pet scan),1 pt groin access site bleeding (surgical repair)
- Median follow-up: 2.4 yrs: 6/15 pts had recurrences but no VT storm and effective anti-tachy therapy/ICD on beta-blocker.

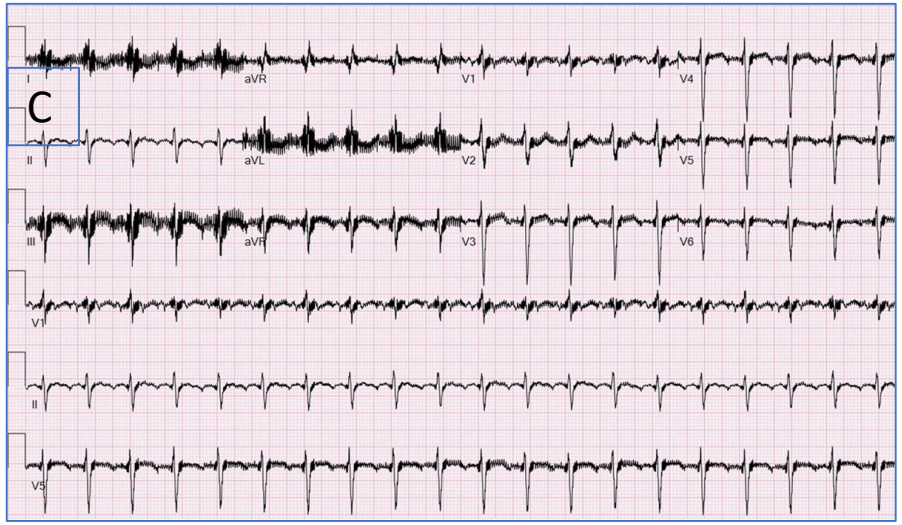
Practical observation from Catheter ablation Protocol

- Clinical VT 12-lead ECG or ICD EGM of VT should be available.
- Evaluation of EMI on12 lead ECG and intracardiac recording filtering set-up to minimize the EMI (LVAD EMI - high frequency noise - adjustment of low-pass filter, HeartMate III has highest EMI)
- CXR and Pre-procedure Cardiac CT angio: LVAD hardware evaluation and cardiac anatomy assessment including CS/cardiac veins and thrombus.
- Intra-cardiac reference for 3-D mapping: selective cardiac vein close to the VT substrate with clean or low EMI EGM. (4-F deflectable multi-electrode or 2 F multi-electrode catheter. Closer to the inflow cannula higher the EMI)

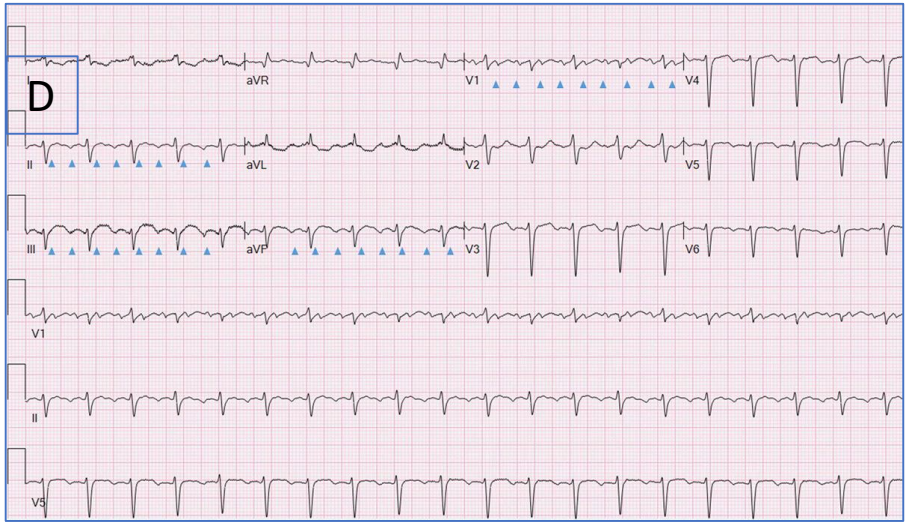
Example of 12 lead ECG from LVAD pts

Pace-mapping

Clinical polymorphic/VF



Standard 12 lead ECG

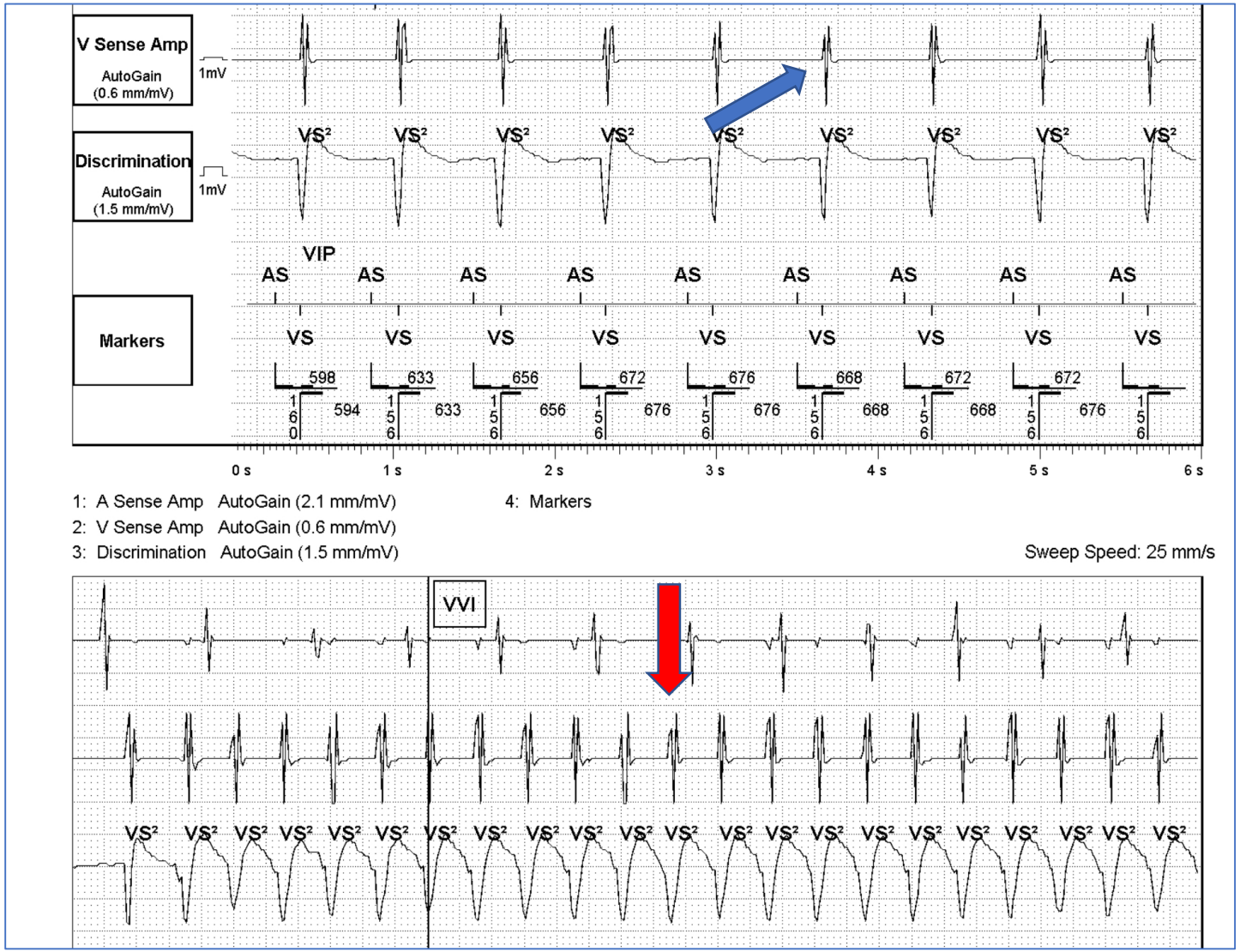


Filtered 12 lead ECG

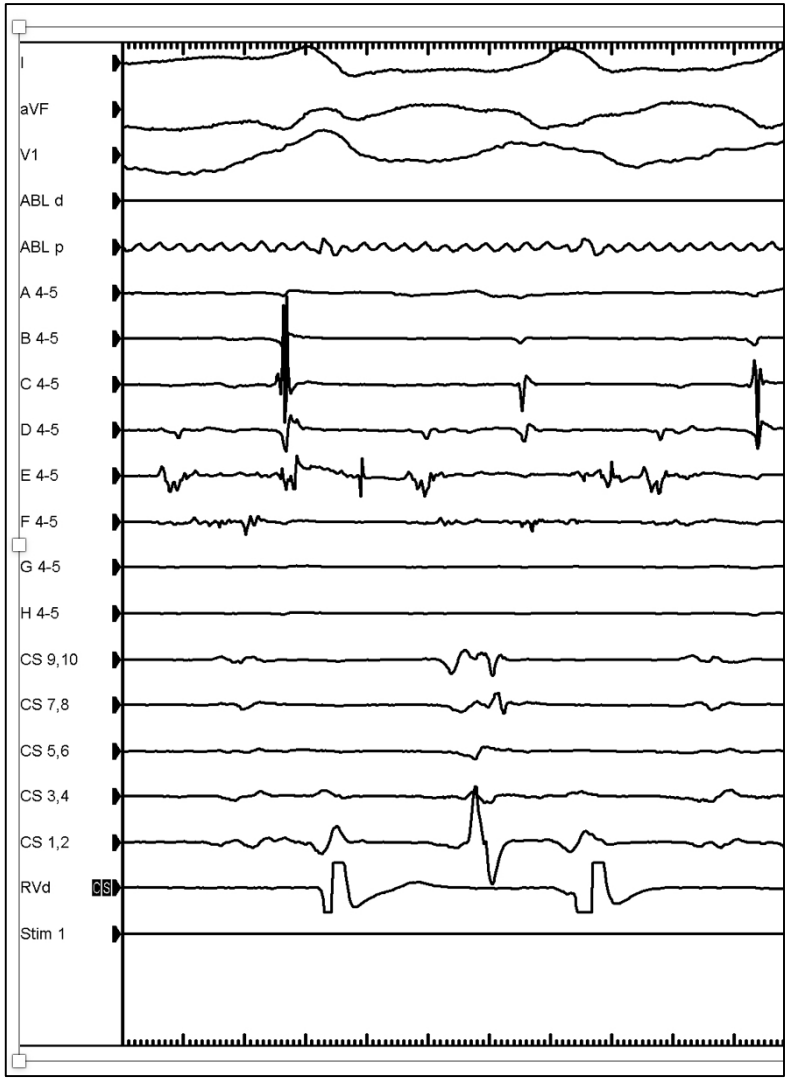
Most of the time presence of noise during 12 lead ECG can predict level of intra-cardiac EGM noise

Panel C and D are from same pt: Panel-C. pre-filter ECG Panel D post filter adjustment ECG

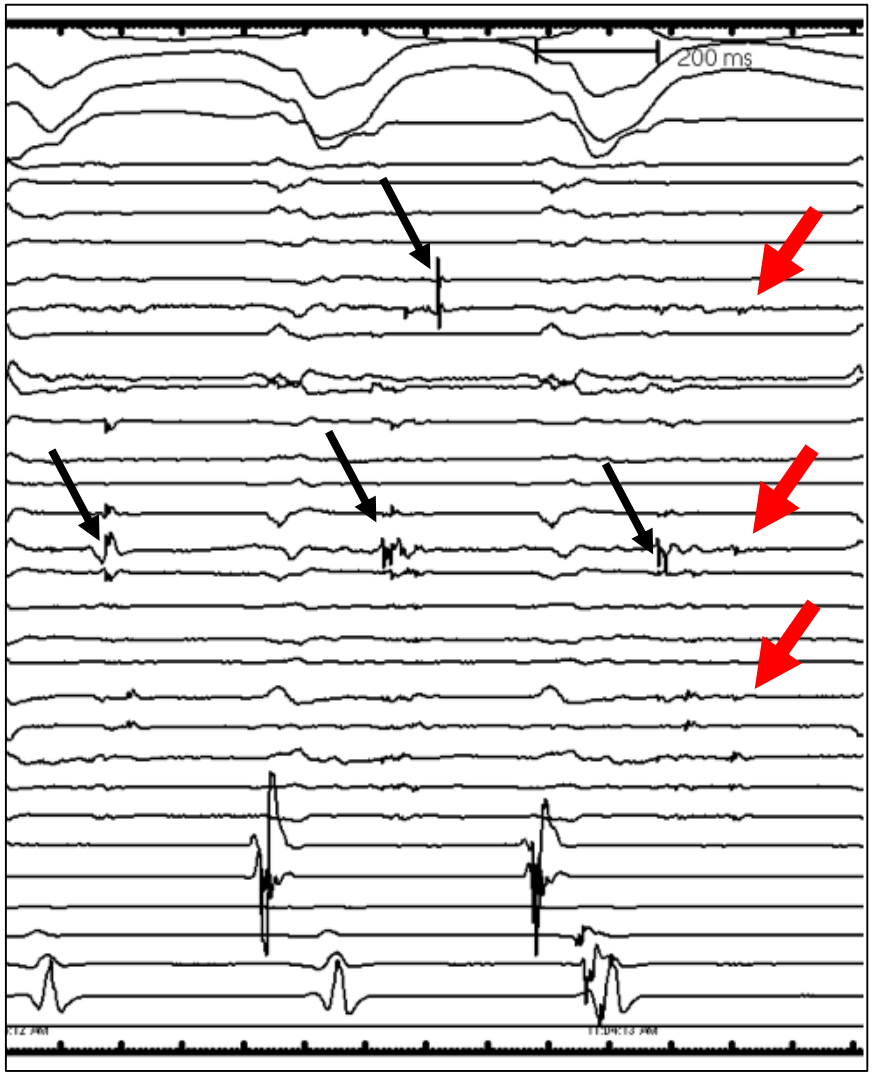
Intracardiac EGM from ICD: DCM - BBB Reentry VT



Filter effects on intra-cardiac EGM

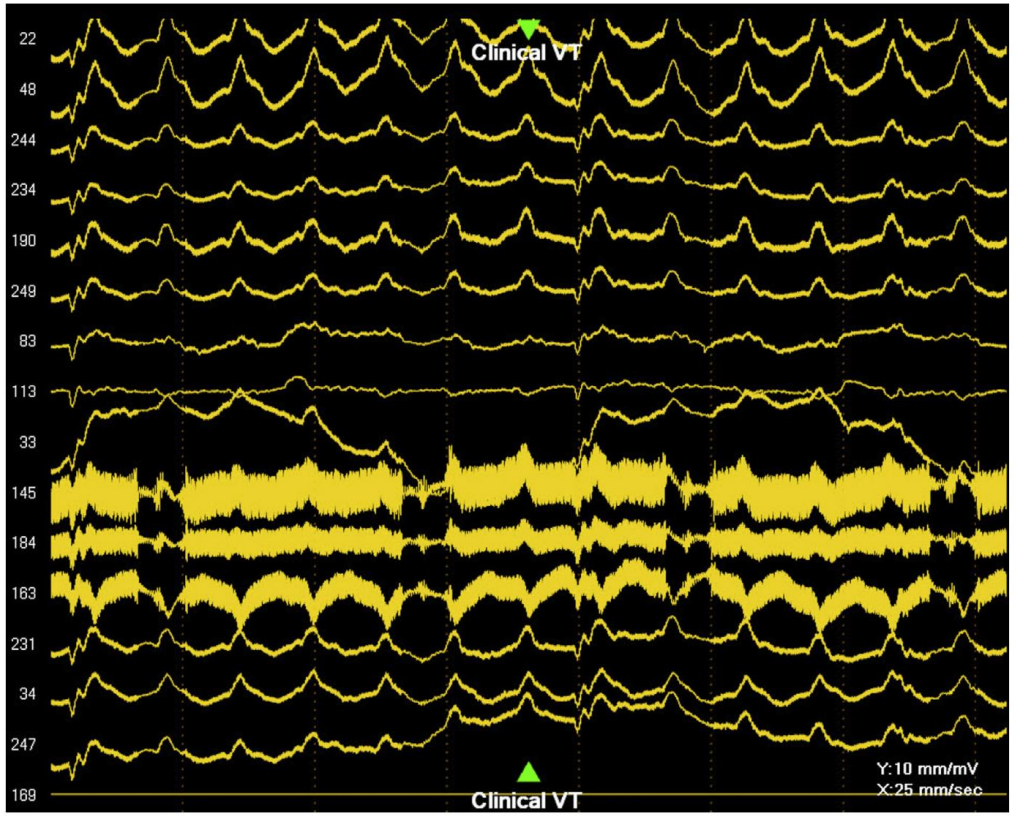


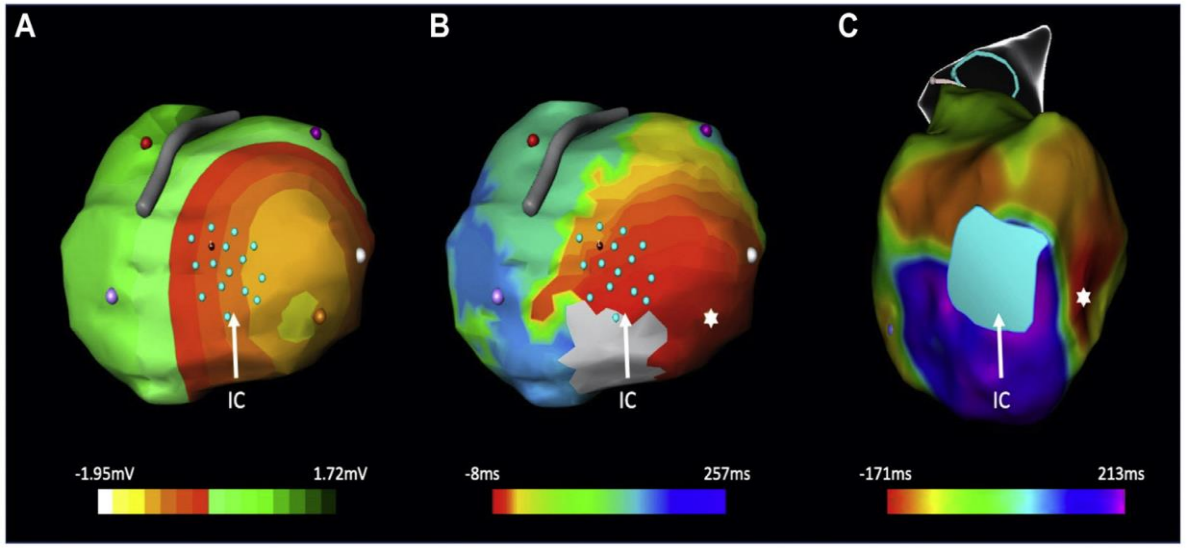
Normal Filter setting: 30 to 500 Hz



LVAD filter setting: 30 to 150 Hz.

Noninvasive electrocardiographic mapping of ventricular tachycardia in a patient with a left ventricular assist device

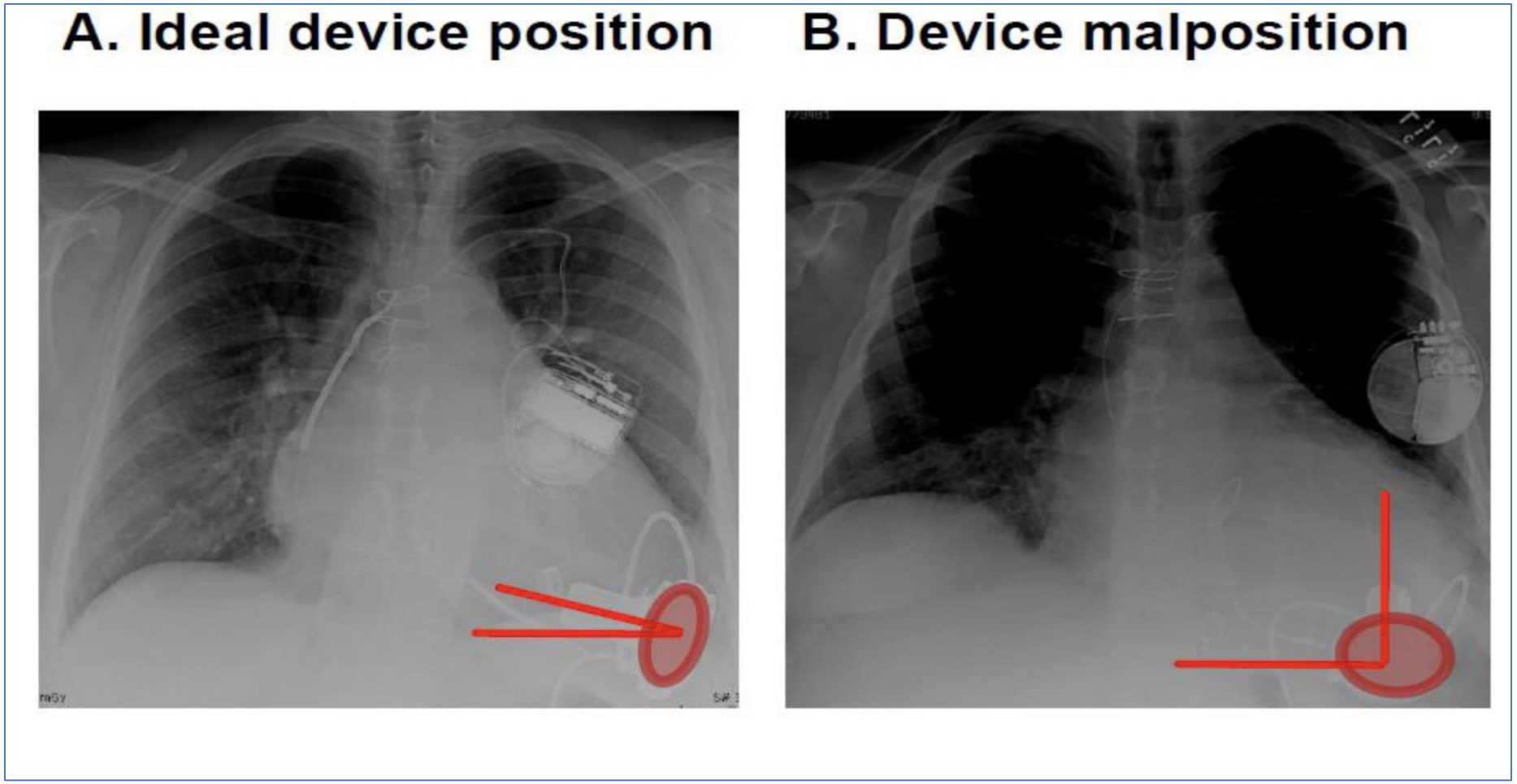




Epicardial EGM based mapping

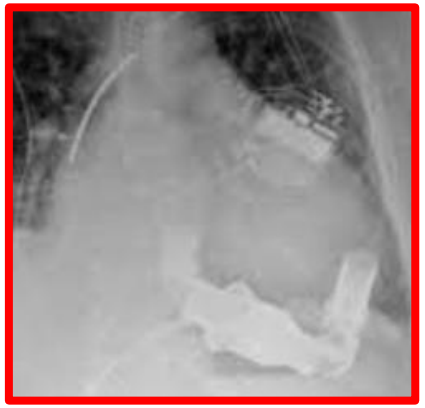
Michael R. Rehorn, Heart Rhythm Case Reports 2020;6:398–401)

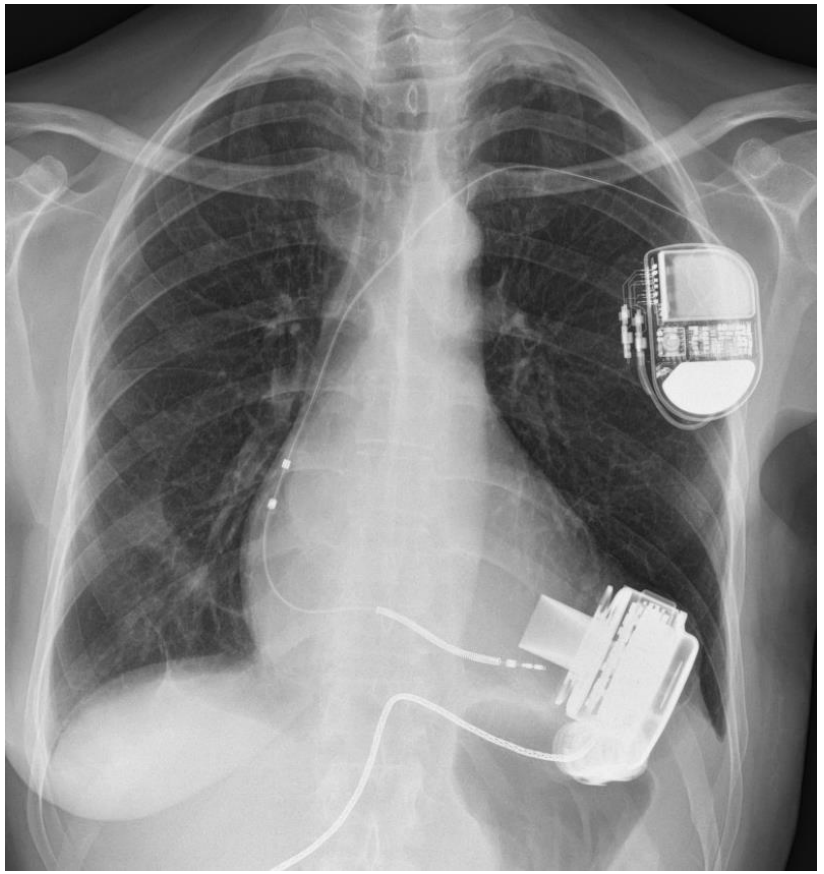
CXR evaluation- LVAD placement
(away from septum)



Imamura and Narang: Medicina ,15 August 2020

CXR from LVAD evaluation





Pts with red mark had much long procedure.

1) difficult catheter manipulation mapping and ablation
2) Poor EGM due to the strong EMI proximity to inflow cannula

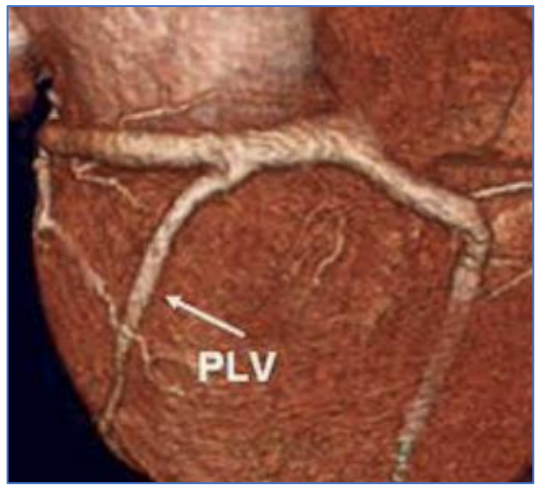
Cardiac CT Imaging

1) Evaluation of cardiac anatomy including CS and cardiac vein to guide mapping, reference catheter placement and ICE imaging.

2) exclude thrombus from LAA and aortic root;

3) LVAD complications (thrombus, infection and canula obstruction)

CT angio for cardiac vein evaluation



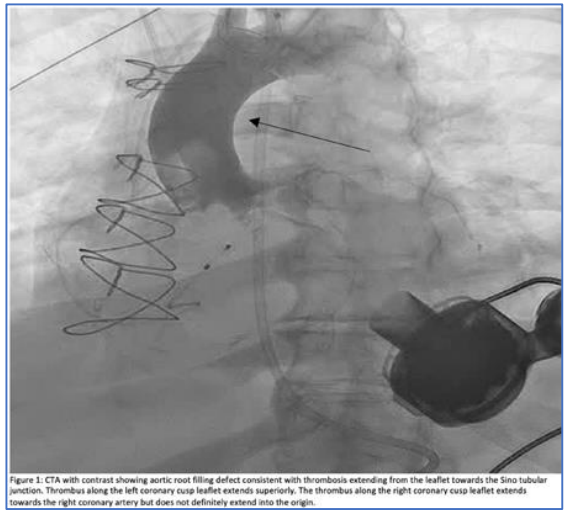
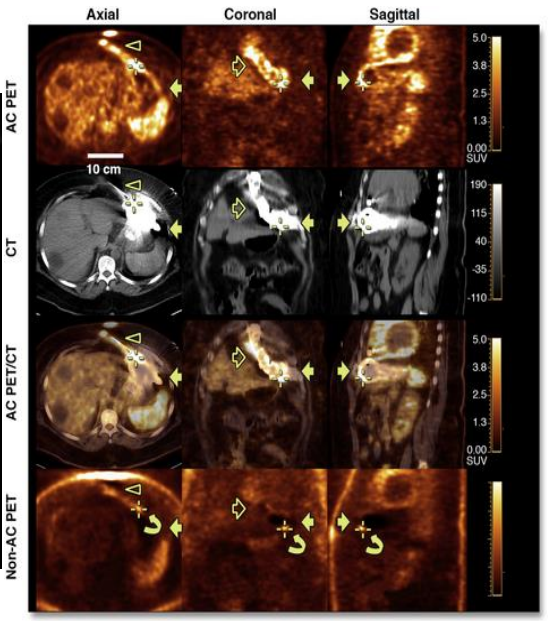


Figure 1: CTA with contrast showing aortic root filling defect consistent with thrombosis extending from the leaflet towards the Sino tubular junction. Thrombus along the left coronary cusp leaflet extends superiorly. The thrombus along the right coronary cusp leaflet extends towards the right coronary artery but does not definitely extend into the origin.

Buttar R et al. circulation 46, 8-10 2022

Asawaeer M et al. *J ACC* 2020; 2:1454-1456.



Kim et al. *JACC*2014; 7:839-842.

Vascular access and puncture technique

- LVAD Pts are always heavily anticoagulated with chronic anti-coagulation with warfarin (INR: 3.5). Vascular complications can result in serious complications including death. (ACT =350 sec)
- Minimize the vascular access number and use mostly venous access
- All vascular access should be performed under the ultrasound guided using micro-puncture needle especially arterial access. (continuous-flow LVAD: very low pulse volume especially under the general anesthesia).
- Single trans-septal with **large curve** deflectable sheath
- Arterial line for monitoring : radial approach (per anesthesia).
- Femoral artery cannulation for trans-aortic approach is planned. (high risks pts for trans-septal catheterization, mechanical MV and PFO closure device)
- No protamine is used during the procedure and use closure devices to seal all puncture sites. (arterial and vein)

Trans-septal catheterization

- Fluoroscopy-ICE guided - low posterior puncture of FO for better support during catheter manipulation
- Post-procedure puncture site seal (minimize residual ASD)
- Large curve deflectable sheath to maintain access to LV via trans-mitral valve.

Trans-aortic approach catheter ablation

- Trans-aortic approach can be associated with increased risks for thrombo-embolic events
- ICE imaging from home and CS view to evaluate presence of thrombus in peri-cuspid sinus of aortic valve. Continue to monitor guide wire crossing of aortic valve
- Trans-aortic valve crossing with mapping and ablation catheter can be challenging especially small aortic valve opening. (temporary-set of LVAD in lower speed to increase opening and monitor LV volume with ICE)
- Place long SL-1 sheath (>90 cm) over “J” wire and cross aortic valve with guide wire and place long sheath over the wire into the LV. This will facilitate catheter exchanges and reduce the risk for embolism.


Map Point Catheter ECG Display Imaging Window Tools Help
Setup
Study Loc. Cath. Map
Mapping
Ablation
Sound
BORAMAE Hosp.
22/06/2023 09:22:21
AcuNav8
GE_Carto
CS OS
Intracardiac echo images from CS
Courtesy of Dr Lim - Borame MED CTR
Playing Clip
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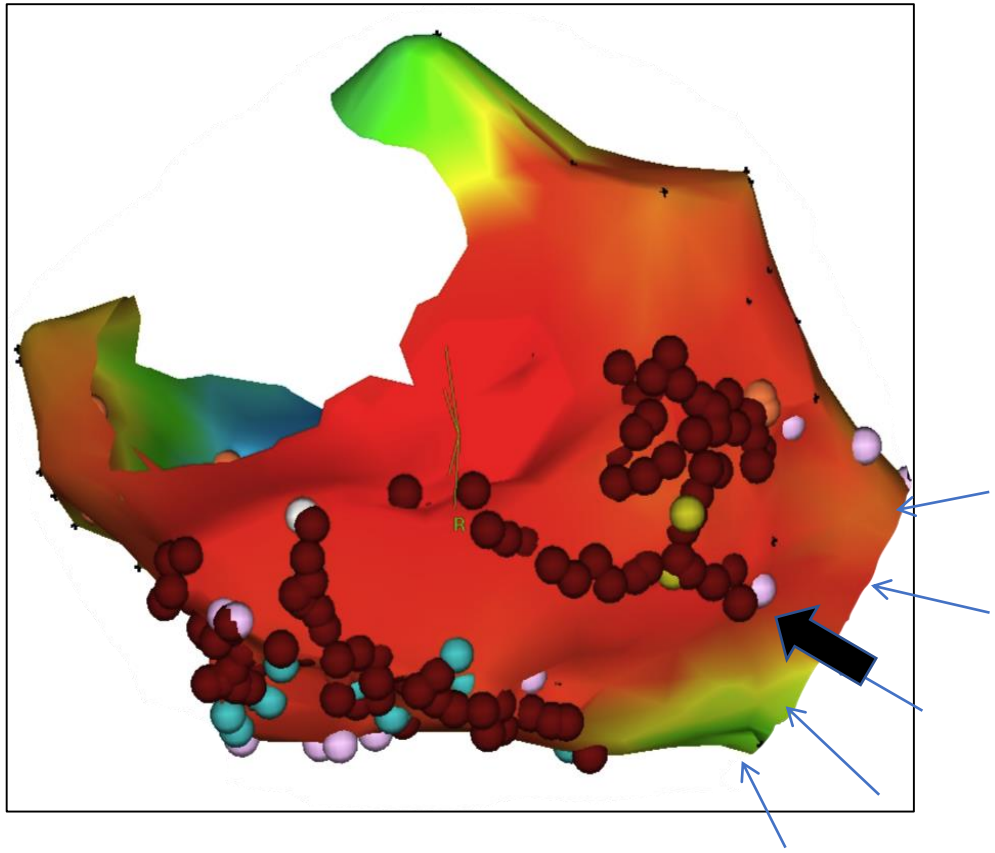
Mapping technique and challenges

- Activation mapping during VT and Entrainment pacing to confirm critical isthmus is preferred methods
- Minimize the prolonged VT episodes and number of VT inductions.
- Ablation catheter may not record low amplitude signal due to the EMI and poor contact due to the anatomical issue (inflow cannula position)
- 3-D mapping may not be accurate (ventricular volume change)
- Check accuracy of 3-D map geometry using contact sensor ablation catheter around ventricle and ICE prior to ablation.

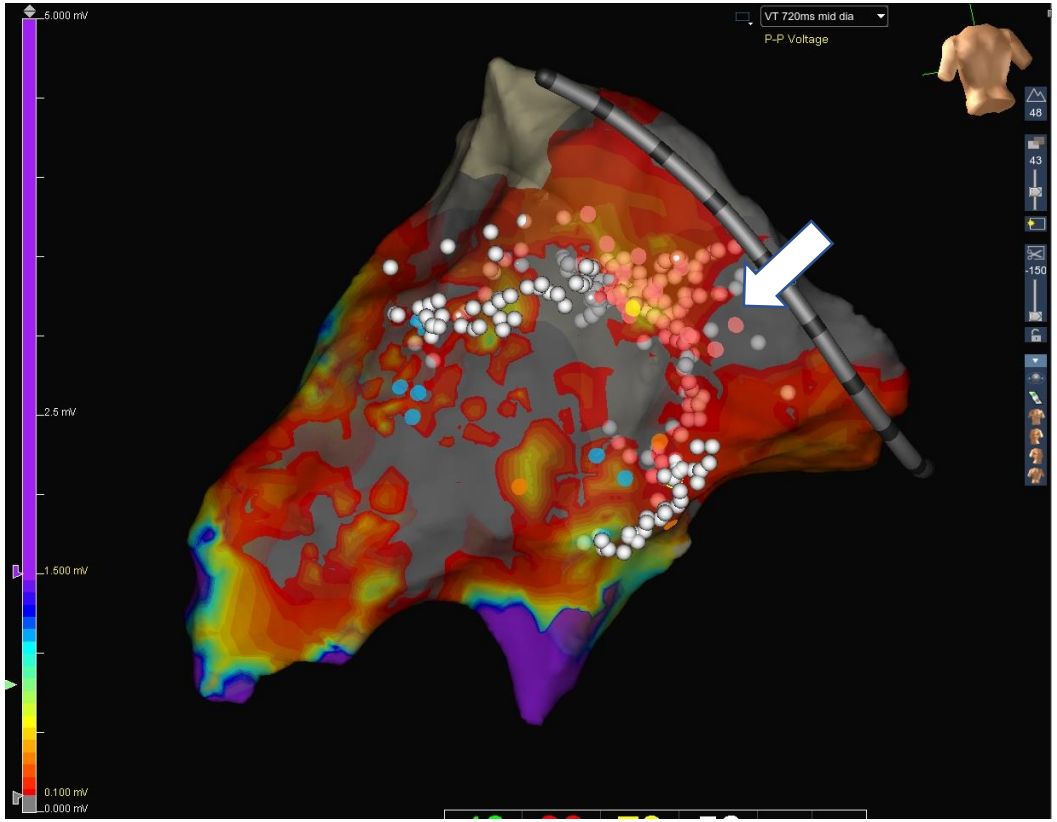
High density substrate mapping for ablation (continued)

- Critical isthmus ablation with contact sensor catheter during VT
- Extend linear ablation to margin inflow cannula marker. To improve catheter stability around the cannula reduce the pump speed short period.
- Keep the last point of linear ablation short from the previous marked margin of cannula.
- The linear ablation from critical isthmus to MV annulus is less effective (difficult trans-mural lesions) due to thick basal myocardium and also this area is not amenable to epicardial ablation
- CS and lateral cardiac vein large enough to deliver ablation energy may be evaluated as option.

Mapping and ablation technique



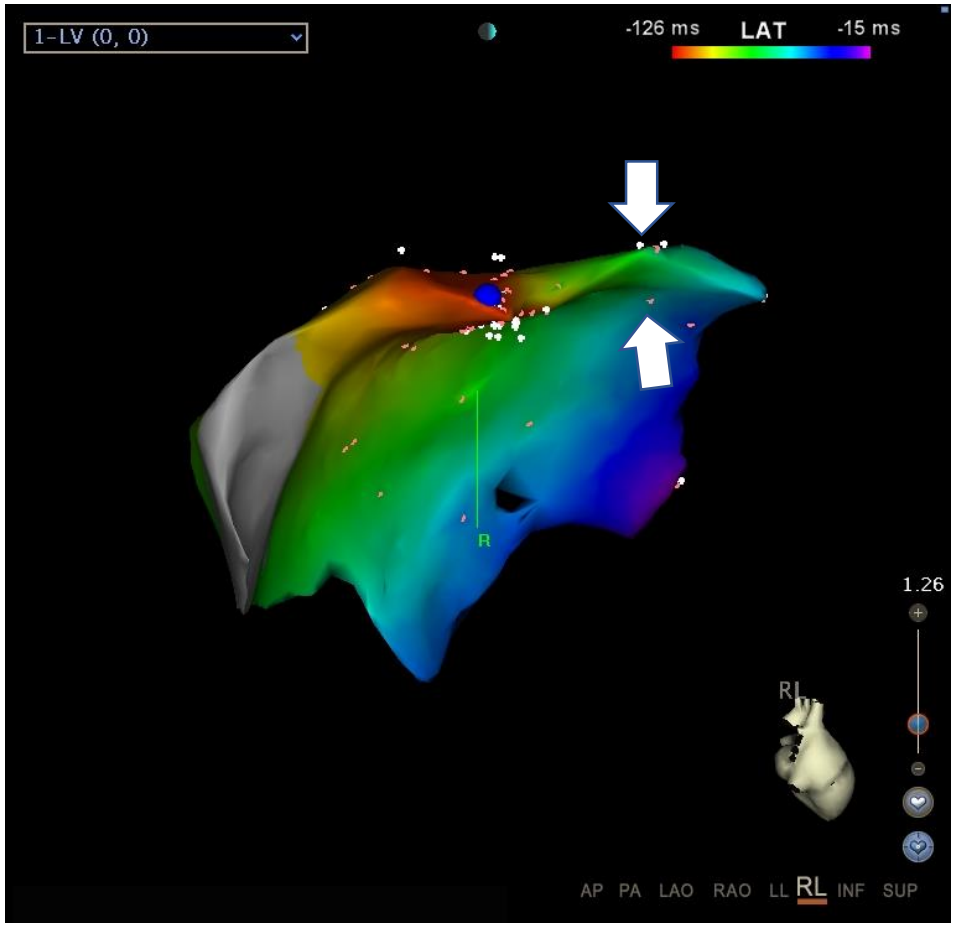
Critical circuit and substrate ablation extended to the proximal region of inflow cannula upper



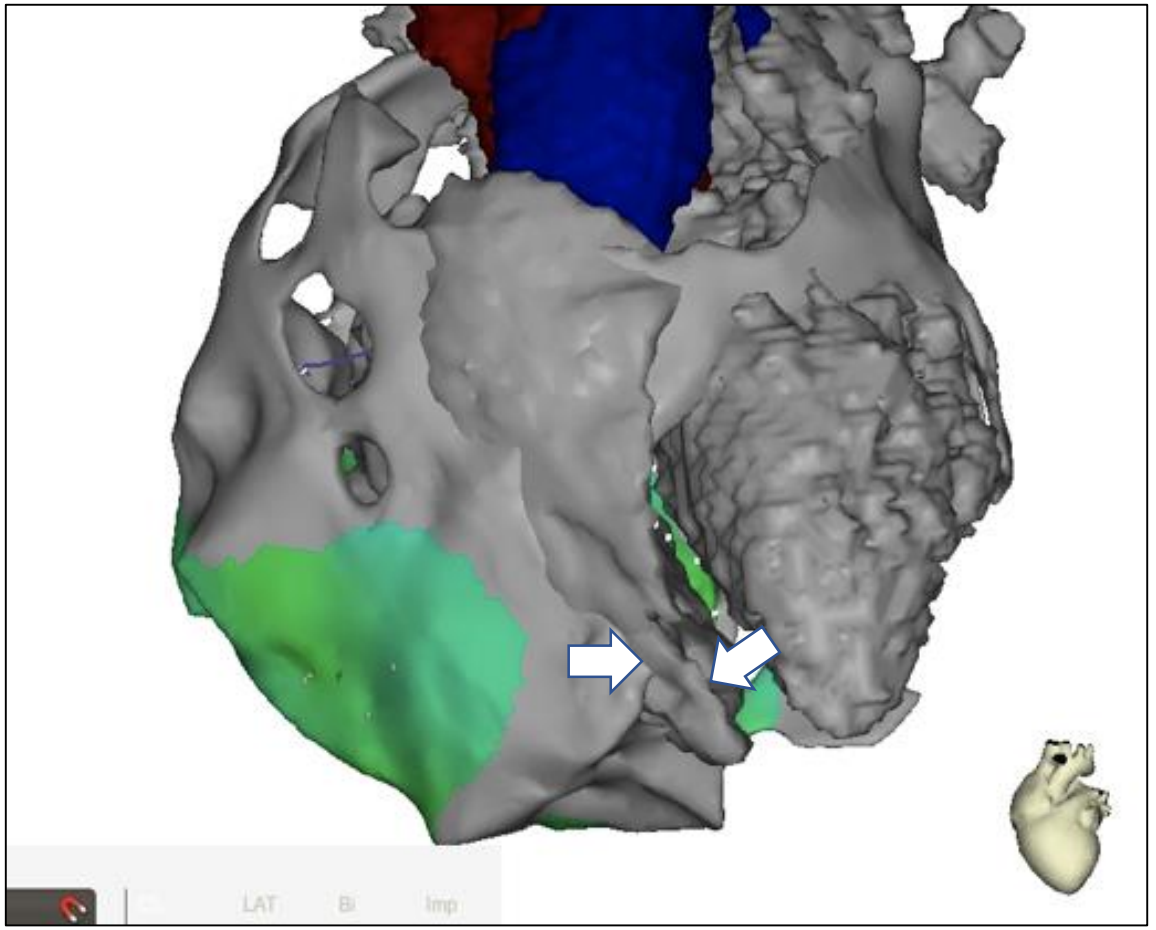
Critical circuit and substrate ablation extended to MV annulus. After extensive ablation re-map showed gap (white arrow)

V Volume dependent 3-D Map change

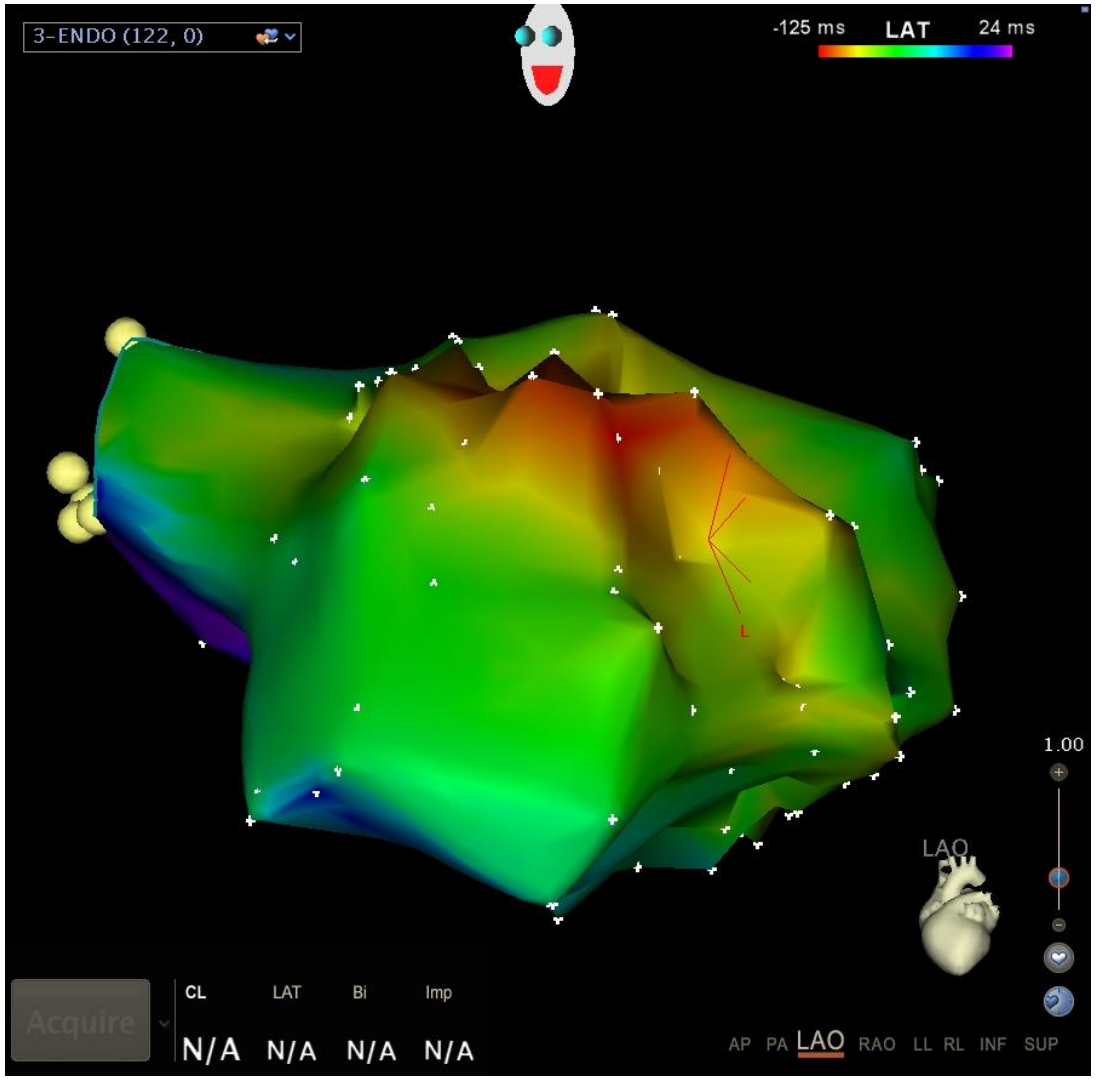
3-D point difference due to the volume increase

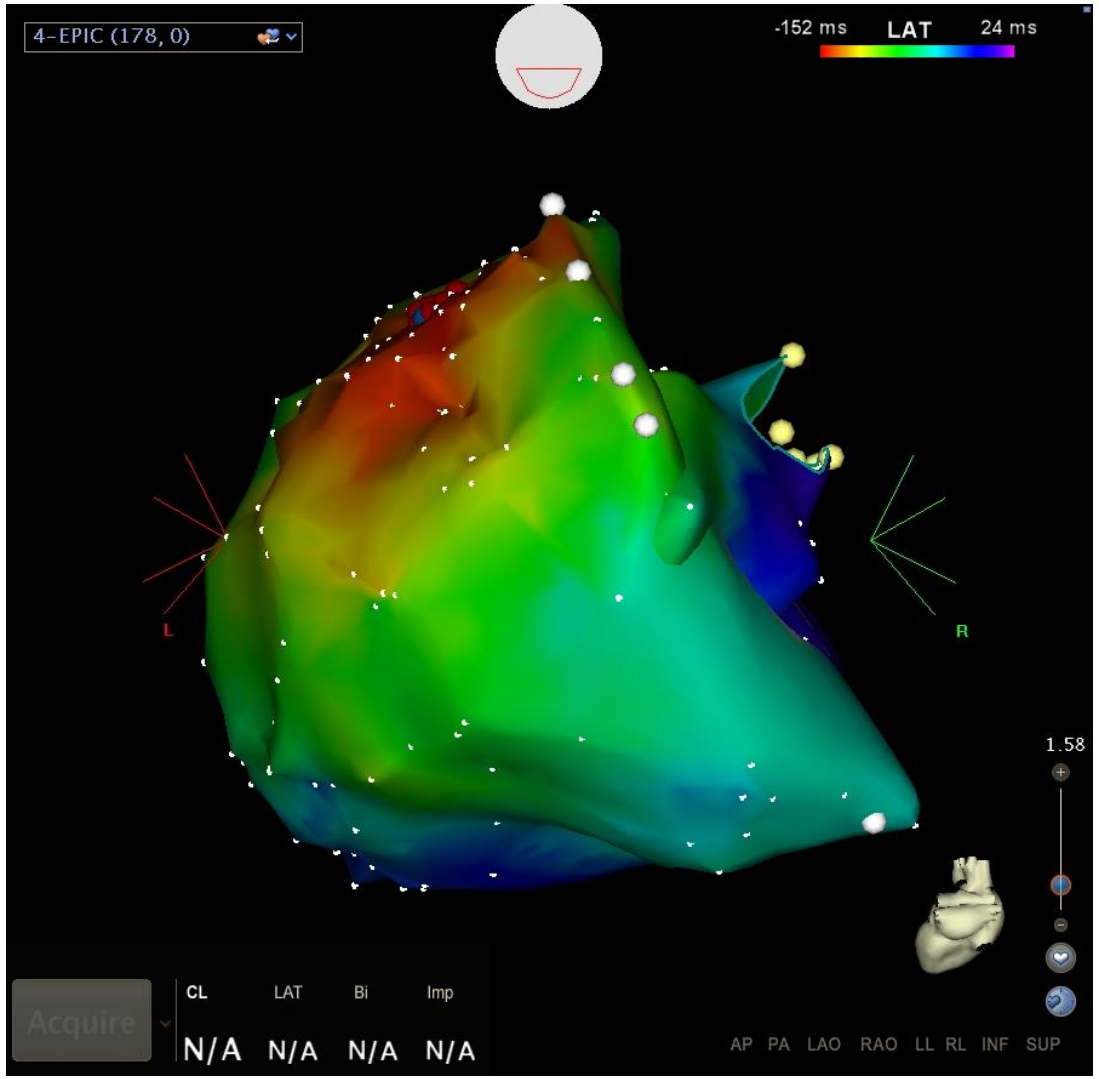


Re-map: new map showed significant difference from initial map in RV VT



Hybrid Surgical Epicardial VT Ablation (failed endocardial ablation)





RV failure monitoring VT ablation

- RV failure exacerbation is one of the factor that determine VT ablation procedure tolerance and acute outcome.
- ICE monitoring is important throughout the procedure try to maintain same volume
- Intra-procedure support for RHF should be available: pump speed adjustment, Impella RP catheter insertion ?
- Metabolic acidosis correction

Summaries

- Early recurrent VT or VT storm have significantly influence survival post LVAD implant
- LVAD pts have significant co-morbidities that increase risks for complications during VT ablation.
- VT management including ablation should be multi-disciplinary team effort.
- Hybrid EP lab with hemodynamic support capable is ideal setting for ablation
- Ablation methods are not different compared non-LVAD HF pts but meticulous attentions with detail preparation is essential to avoid complications
- Team approach VT ablation protocol should be developed before start the VT ablation program.
- VT ablation in LVAD pts has acceptable short term outcomes but long term data from registry or higher number cases needed

Thank you for your attention