HOW TO DECIDE ON AN INITIAL APPROACH: ENDO, EPI, OR BOTH?

Noel G. Boyle MD PhD, Jason Bradfield MD, Kalyanam Shivkumar, MD PhD

UCLA Cardiac Arrhythmia Center

UCLA Interventional Cardiovascular Programs | UCLA Neurocardiology Research Center of Excellence

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UCLA Cardiac Arrhythmia Center

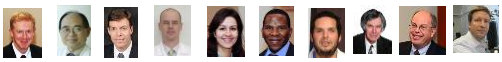
The mission of the UCLA Cardiac Arrhythmia Center is to generate new knowledge in the field of cardiac electrophysiology and cardiovascular therapeutics

ICMR Indian Council of Medical Research

UCLA Specialty Training & Advanced Research | American Heart Association

NIH National Institutes of Health *Turning Discovery Into Health*

DISCLOSURES: University of California (UCLA campus) has patents developed by my group in the areas of catheter technology, embolism prevention technology, minimally invasive methods for cardiac interventions, cardiac neural diagnostics and therapeutics



Contemporary Reviews in Cardiovascular Medicine

Epicardial Interventions in Electrophysiology

Noel G. Boyle, MD, PhD; Kalyanam Shivkumar, MD, PhD

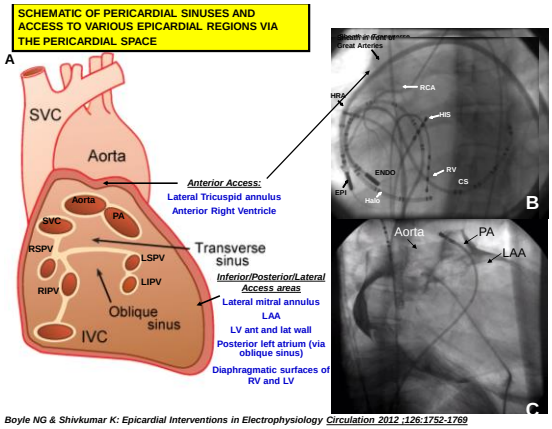
Circulation. 2012;126:1752-1769

Acknowledgements

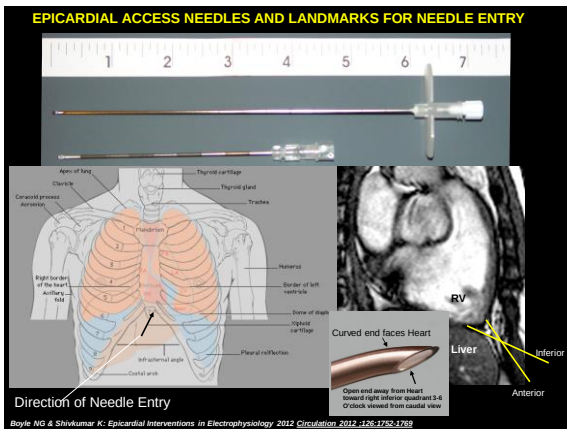
The authors dedicate this review to Drs Eduardo Sosa, Mauricio Scanavacca, Andre D'Avila, and their EP and cardiology colleagues for their pioneering work on epicardial ablations at the Incor Institute, Sao Paulo, Brazil. Their generosity in hosting and training several teams around the world in this approach is also appreciated. We also thank our colleagues, staff, and trainees in the past decade who have all participated in these procedures as they evolved at our center.

When to go epicardial

- General concepts
- ECG criteria
- Etiology & Imaging criteria



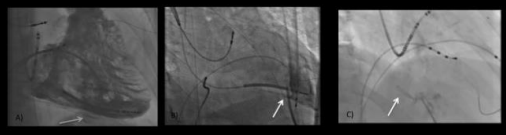
Boyle NG & Shivkumar K: Epicardial Interventions in Electrophysiology Circulation 2012 ;126:1752-1769



Boyle NG & Shivkumar K: Epicardial Interventions in Electrophysiology 2012 Circulation 2012 ;126:1752-1769

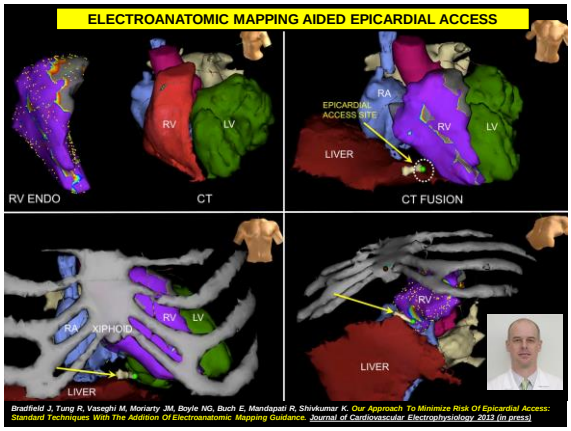
Dangers of Pericardial Access

- RV perforation
- Pericardial bleeding
- Liver Injury
- Abdominal Bleeding
- Entry into left pleural space



epicardial/intramural hematoma | *RV perforation* | *Liver entry*

ELECTROANATOMIC MAPPING AIDED EPICARDIAL ACCESS



Bradfield J, Tung R, Vaseghi M, Moriarty JM, Boyle NG, Buch E, Mandapati R, Shivkumar K. Our Approach To Minimize Risk Of Epicardial Access: Standard Techniques With The Addition Of Electroanatomic Mapping Guidance. Journal of Cardiovascular Electrophysiology 2013 (in press)

Approach to Assessing Need for Epicardial Access/Ablation

1. ECG suggest Epicardial VT exit site (A) (B) — YES → Consider obtaining Epicardial Access for Mapping (and Ablation)
   - NO ↓
2. Prior unsuccessful Endocardial Ablation — YES → Consider obtaining Epicardial Access for Mapping (and Ablation)
   - NO ↓
3. Define SCAR location with CE imaging: Sub epicardial or mid-myocardial scar — YES → Consider obtaining Epicardial Access for Mapping (and Ablation)
   - NO ↓
4. Consider likelihood of Epicardial circuit for Underlying Substrate: (C) — HIGH → Consider obtaining Epicardial Access for Mapping (and Ablation)
   - LOW ↓

Perform Endocardial Mapping and Ablation first

(A) *ECG Criteria (Berruezo et al Circ 2004)*

1) Pseudo-delta >34 ms
2) IDT (V2) >85 ms
3) Shortest RS complex >121 ms
4) QRS duration >211 ms

(B) *ECG Criteria for NICM (Valles E Circ AE 2010)*

1) Absence of inferior Q wave
2) Pseudodelta ≥75 ms
3) MDI >0.59
4) Presence of Q wave in lead I

(C) Probability of Epicardial Focus (Sacher F et al JACC 2010)

Normal	6%
ICM	16%
NICM	35%
ARVC	41%
Other CM	18%

Boyle NG & Shivkumar K: Epicardial Interventions in Electrophysiology, Circulation 2012;126:1752-1769

When to go epicardial

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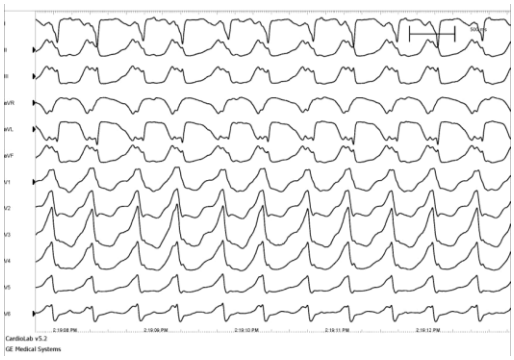
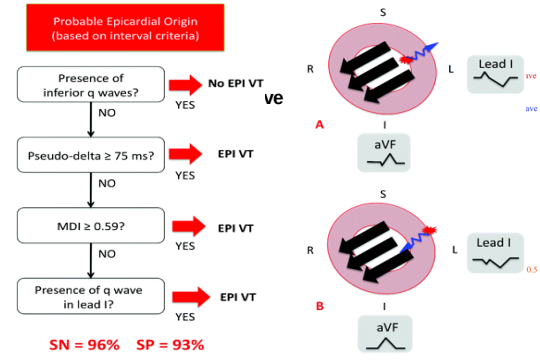
- Etiology & Imaging criteria



ECG CRITERIA FOR NON ISCHEMIC CARDIOMYOPATHY



Valles E, Bazan V, Marchlinski FE. Ecg criteria to identify epicardial ventricular tachycardia in nonischemic cardiomyopathy. Circ Arrhythm Electrophysiol. 2010;3:63-71

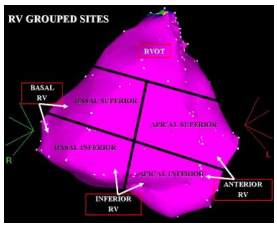
TWELVE-LEAD ECG FEATURES TO IDENTIFY VENTRICULAR TACHYCARDIA ARISING FROM THE EPICARDIAL RIGHT VENTRICLE

1) pseudo-delta >34 ms

2) intrinsicoid deflection time (v2) >85 ms

3) shortest RS complex >121 ms

4) QRS duration >211 ms



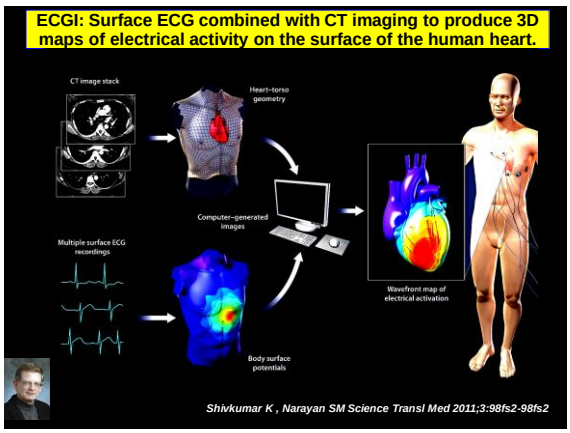
Bazan V, Bala R, Garcia FC, Sussman JS, Gerstenfeld EP, Dixit S, Callans DJ, Zado E, Marchlinski FE. Twelve-lead ECG features to identify ventricular tachycardia arisingfrom the epicardial right ventricle. Heart Rhythm. 2006;3:1132-1139

QRS CHARACTERISTICS FAIL TO RELIABLY IDENTIFY VENTRICULAR TACHYCARDIAS THAT REQUIRE EPICARDIAL ABLATION IN ISCHEMIC HEART DISEASE

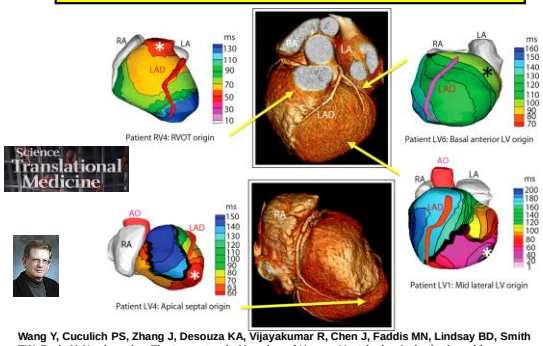
- Pseudodelta wave (PdW)
- Intrinsicoid deflection time (IDT)
- Shortest RS complex (SRS)
- QRS duration (QRSd)
- Maximum deflection index (MDI)
- Q or q wave in lead I (QWL1)
- Absence of q waves in inferior leads aVR/aVL ratio

Martinek M, Stevenson WG, Inada K, Tokuda M, Tedrow UB. QRS characteristics fail to reliably identify ventricular tachycardias that require epicardial ablation in ischemic heart disease. J Cardiovasc Electrophysiol. 2012;23:188-193

ECGI: Surface ECG combined with CT imaging to produce 3D maps of electrical activity on the surface of the human heart.



ECGI ISOCHRONE MAPS FOR LOCALIZATION OF VT SITE OF ORIGIN



Wang Y, Cuculich PS, Zhang J, Desouza KA, Vijayakumar R, Chen J, Faddis MN, Lindsay BD, Smith TW, Rudy Y. Noninvasive Electroanatomic Mapping of Human Ventricular Arrhythmias with Electrocardiographic Imaging. *Science Translational Medicine. 2011* 3(98):98ra84.

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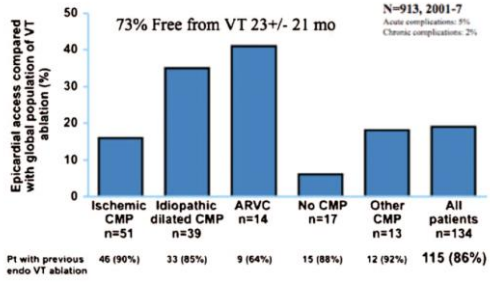
Substrate and Epicardial Ablation



Sacher F, Roberts-Thomson K, Maury P, Tedrow U, Nault I, Steven D, Hocini M, Koplan B, Leroux L, Derval N, Seiler J, Wright MJ, Epstein L, Haissaguerre M, Jais P, Stevenson WG. Epicardial ventricular tachycardia ablation a multicenter safety study. *J Am Coll Cardiol.* 2010;55:2366-2372

SUMMARY: EPI, ENDO or BOTH

1. ECG suggest Epicardial VT exit site (A) (B) YES → Consider obtaining Epicardial Access for Mapping (and Ablation)
   NO
2. Prior unsuccessful Endocardial Ablation YES →
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Boyle NG & Shivkumar K: Epicardial Interventions in Electrophysiology, Circulation 2012;126:1752-1769

Outcomes of Combined Epicardial and Endocardial Ablation

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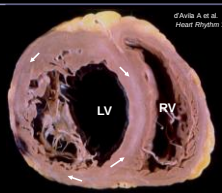
Director, Electrophysiology Lab
Icahn School of Medicine at Mount Sinai
New York, NY

Scar-Related VT

Myocardial Infarction

- Coronary artery territory
- Subendocardial or transmural
- Epicardial scar present in ~10%[1]



d'Avila A et al.
Heart Rhythm 2006

Dilated Cardiomyopathy

- Mid-myocardial & epicardial, patchy or longitudinal striae
- Scar progression over time[2]
- Basal – perivalvular[3]
- Anteroseptal & inferolateral scar location in 89% of those with VT[4]

[1]Verma A et al. *JCE* 2005;16:465-71
[2]Liuba I et al. Heart Rhythm 2014;11:755-62
[3]HH et al. *Circulation* 2003; 108:704-10
[4]Piers S et al. Circ EP 2013;6:875-83

Disclosures

- Biosense Webster – Research Grant

Post-MI: Endo–Epicardial Homogenization

Di Biase L et al – *JACC* 2012;60:132-41

- 100% non-inducibility achieved in both groups

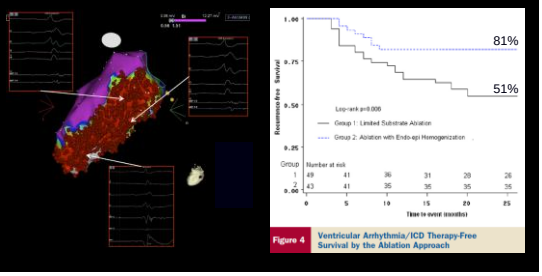
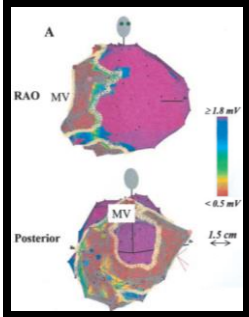


Figure 4 Ventricular Arrhythmia/ICD Therapy-Free Survival by the Ablation Approach

DCM: Endocardial Ablation



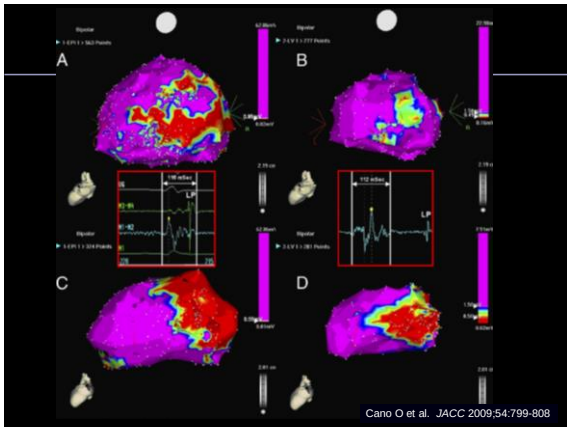
Hsai HH et al – *Circ* 2003; 108:704-10

- 19 pts with DCM and MMVT
  - Basal (peri-mitral) scar in ***ALL***
  - Endocardial scar <25% of LV
  - Of 57 VTs, 88% of induced VTs were from basal scar
- After ablation, 14/19 (74%) were non-inducible
- *After 22 ± 12 months, only 5 pts (23%) were alive without VT recurrence*

DCM – Epicardial Scar

Cano O et al – *JACC* 2009; 54:799-808.

- 22 pts with DCM and failed prior endocardial ablation (n=20) or VT suggestive of epicardial origin (n=2)
- Combined epicardial/endocardial mapping was performed
- Scar Location
  - **Epicardial scar in 18 pts (82%)** – basal LV/lateral wall
  - Endocardial scar in 12 pts (54%) – basal LV
- Scar Area
  - **Epicardial = 55.3 ± 33.5 cm^2**
  - Endocardial = 22.9 ± 32.4 cm^2 ($p < 0.01$)
- F/U 18 ± 7 months
  - 71% free of VT



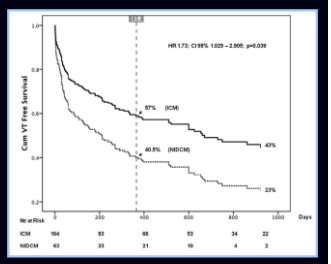
Cano O et al. *JACC* 2009;54:799-808

Single Procedure VT-free Survival: ICM vs. NICM

Results From the Prospective Heart Centre of Leipzig VT (HELP-VT) Study

Dinov B et al –
Circulation 2014;129:728-36

- 224 pts. (ICM 164, NICM 63)
- Epicardial ablation:
  - ICM 1.2%
  - NICM 30.8%
- Acute procedural success (non-inducibility of VT):
  - ICM 77.4%
  - NICM 66.7%

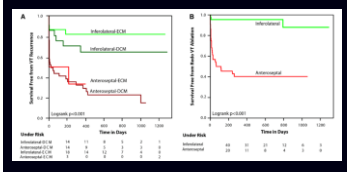


Catheter Ablation of Ventricular Arrhythmia in Nonischemic Cardiomyopathy

Anteroseptal Versus Inferolateral Scar Sub-Types

Teresa Oloriz, MD; John Silberbauer, MD (Res), MRCP; Giuseppe Maccabelli, MD; Hiroya Mizuno, MD, PhD; Francesca Baratto, MD; Senthil Kirubakaran, MD, MRCP; Pasquale Vergara, MD, PhD; Caterina Bisceglia, MD, PhD; Giulia Santagostino, MD; Alessandra Marzi, MD; Nicoleta Sora, MD; Carla Roque, MD; Fabrizio Guarracini, MD; Dimitris Tsiachris, MD, PhD; Andrea Radinovic, MD; Manuela Cireddu, MD; Simone Sala, MD; Simone Gulletta, MD; Gabriele Paglino, MD; Patrizio Mazzone, MD; Nicola Trevisi, MD; Paolo Della Bella, MD

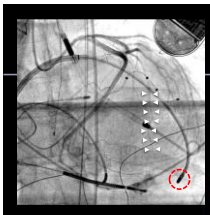
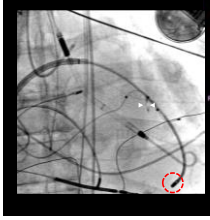
Circ EP 2014;7:414-23



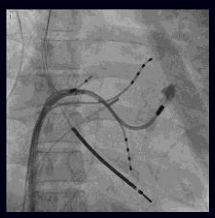
- 87 pts. with NICM and VT:
  - Anteroseptal scar 44
  - inferolateral 43
- Presence of anteroseptal scar was associated with a HR 5.5 (p<0.001) for VT recurrence

ECM: early CM
DCM: LVEF<45%, mod-severe LV dilatation

Transcoronary Ethanol Ablation

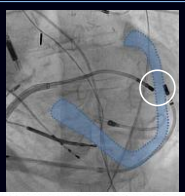
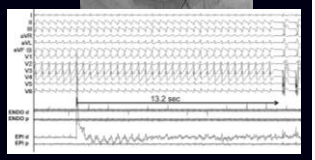




INFUSION NEEDLE ABLATION

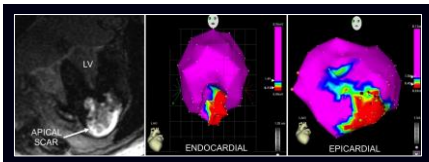


Sapp J L et al. *Circ* 2013;128:2289-2295

BIPOLAR RFA

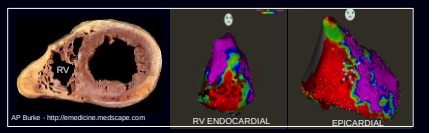



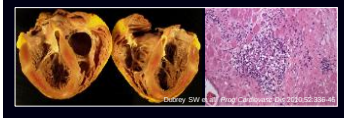
Koruth JS et al. *Heart Rhythm* 2012;9:1932-41



HCM

ARVC





Cardiac Sarcoidosis

Hypertrophic Cardiomyopathy

Long-Term Outcomes of Combined Epicardial and Endocardial Ablation of Monomorphic Ventricular Tachycardia Related to Hypertrophic Cardiomyopathy

Srinivas R. Dukkipati, MD; Andre d'Avila, MD; Kyoko Soejima, MD; Rupa Bala, MD; Keiichi Inada, MD; Sheldon Singh, MD; William G. Stevenson, MD; Francis E. Marchlinski, MD; Vivek Y. Reddy, MD

Circ EP 2011;4:185-194

- 10 pts. with HCM & drug refractory VT undergoing combined epicardial-endocardial ablation
- **Epicardial scar present in 8/10 (80%)**
- Acute procedural success: 89%
- At 37 ± 17 months – 78% VT free

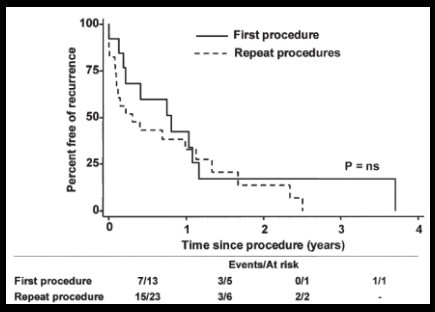
Radiofrequency catheter ablation of ventricular arrhythmias in patients with hypertrophic cardiomyopathy: safety and feasibility

Pasquale Santangeli,*†‡§ Luigi Di Biase, MD,*†‡ Dhanunjay Lakkireddy, MD,‖ J. David Burkhardt, MD,* Jayanne Pelargonio, MD,* Yoav Michowitz, MD,¶ Javier E. Sanchez, MD,* Rodney Horton, MD,*† Pasquale Mohanty, MBBS, MPH,* G. Joseph Gallinghouse, MD,* Antonio Dello Russo, MD,‡ Michela Casella, MD,‡ Gemma Pelargonio, MD,‡ Pietro Santarelli, MD,‡ Atul Verma, MD,* Casimir Narasimhan, MD,** Kalyanam Shivkumar, MD,¶ Andrea Natale, MD, FACC, FHRS*†‡§

Heart Rhythm 2010;7:1036-42

- 22 pts with HCM & drug refractory VT undergoing catheter ablation
- **Epicardial RFA in 13 pts (59%)**
- Acute procedural success: 86%
- At 20 ± 9 months – 73% VT free

ARVC-VT: Endocardial Ablation



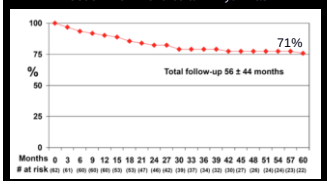
Dalal et al *JACC* 50:432, 2007

ARVC-VT: Combined Endocardial & Epicardial Ablation

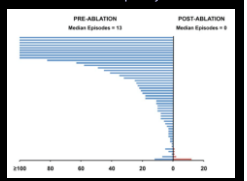
Santangeli P et al – *Circ EP* 2015;8:1413-21

- 62 pts. with ARVC-VT undergoing endocardial ± epicardial ablation
- Follow-up 56 ± 44 months

Freedom from Ventricular Arrhythmias



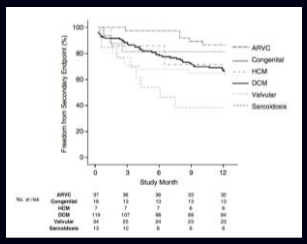
VT Frequency



Catheter Ablation of Ventricular Tachycardia in Nonischemic Heart Disease

Michifumi Tokuda, MD; Usha B. Tedrow, MD, MSc; Pipin Kojodjojo, MD, PhD; Keiichi Inada, MD, PhD; Bruce A. Koplan, MD, MPH; Gregory F. Michaud, MD; Roy M. John, MD, PhD; Laurence M. Epstein, MD; William G. Stevenson, MD

Circ EP 2012;5:992-1000



- 224 pts. with NICM and VT:
- Epicardial ablation:
  - DCM 29%
  - ARVC 30%
  - Sarcoidosis 15%
  - HCM 43%
  - Congenital 6%
  - Valvular 3%
- Secondary endpoint: freedom from death, transplantation, VT hospitalization

Final Thoughts

- Unlike in ischemic VT, scar in other substrates is ***NOT*** predominantly limited to the sub-endocardium
- Epicardial scar present in:
  - ICM ~10%
  - other substrates ≥ 30%
- An endocardial ± epicardial ablation approach
  - best results in ICM and ARVC
  - suboptimal results in DCM (inferolateral scar better than anteroseptal scar) and Cardiac Sarcoidosis
- Better mapping and ablation technologies are necessary to improve outcomes

Role of Imaging Techniques in Catheter Ablation of Ventricular Tachycardia

Amin Al-Ahmad, MD, FACC, FHRS, CCDS
Texas Cardiac Arrhythmia Institute
Austin, Texas

Disclosures

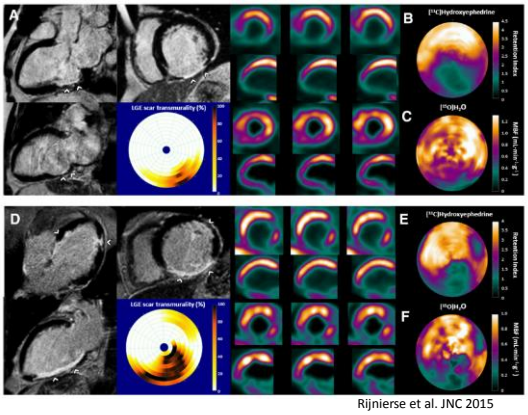
- Medtronic
- St Jude Medical
- Boston Scientific
- Biosense
- Apama Medical
- Khalila Medical

Introduction

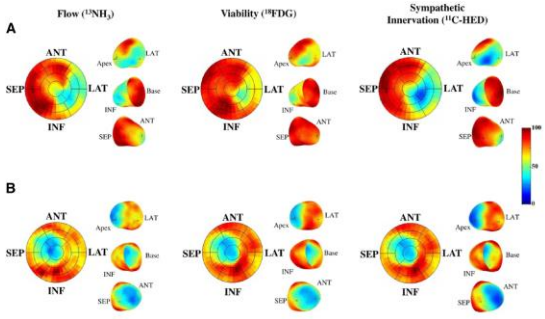
- Pathophysiology of VT in complex
- Interplay between substrate, triggers
- Understanding the substrate is helpful in targeting VT
- Imaging during procedures to guide in ablation and prevent compliactions

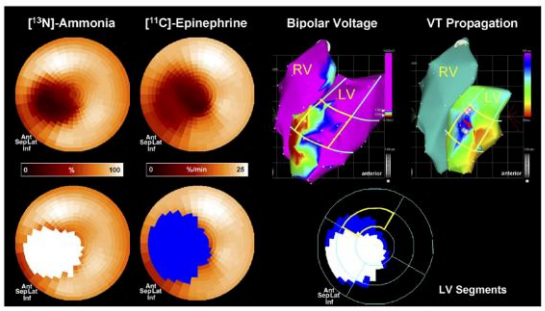
Pre-Procedural Imaging

- Nuclear
  - Perfusion
  - Viability
  - Innervation
- MRI
  - Late enhancement
- CT scan/Rotational Fluoroscopy

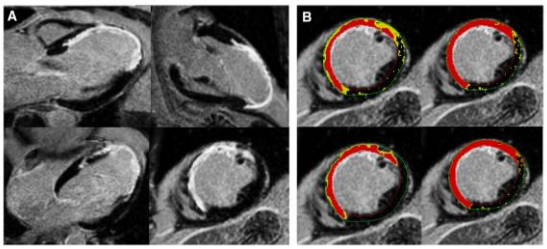


Rijnierse et al. JNC 2015

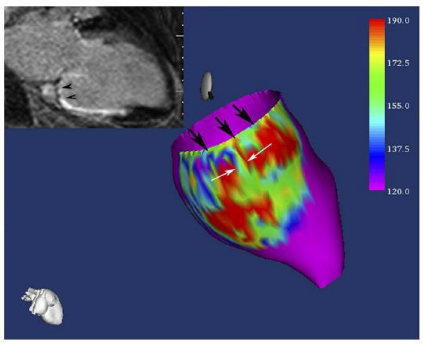




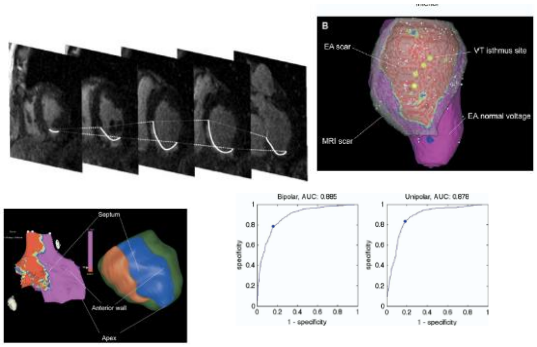
Rijnierse et al. JNC 2015



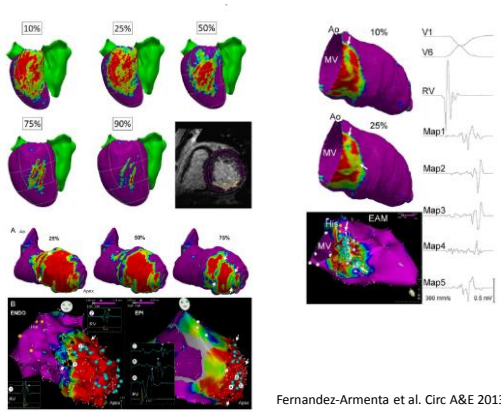
Perez-David JACC 2011



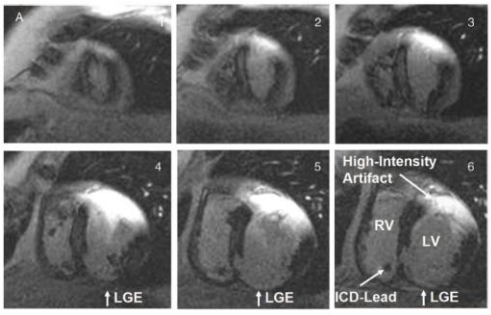
Perez-David JACC 2011



Desjardins et al. HR 2009

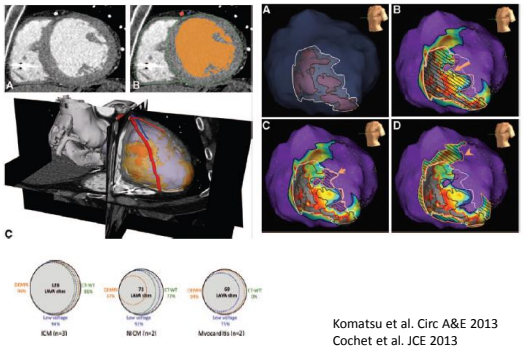


Fernandez-Armenta et al. Circ A&E 2013



Dickfeld et al. Circ A&E 2011

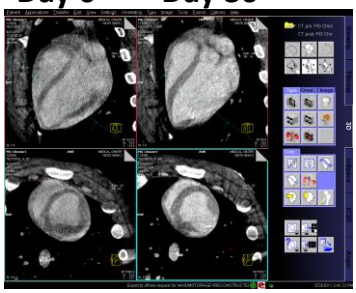
CT Scan- Wall thinning



Komatsu et al. Circ A&E 2013
Cochet et al. JCE 2013

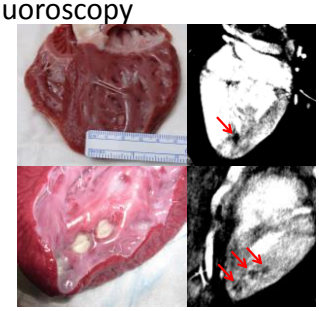
Image of LV scar- Rotational Fluoroscopy

Day 0 **Day 30**



Visualization of RF Lesions--Rotational Fluoroscopy

- 29 RF ablation lesions were created and visualized
- All lesions exhibited a perfusion defect
- 24 lesions (83%) had a peripheral enhancing ring



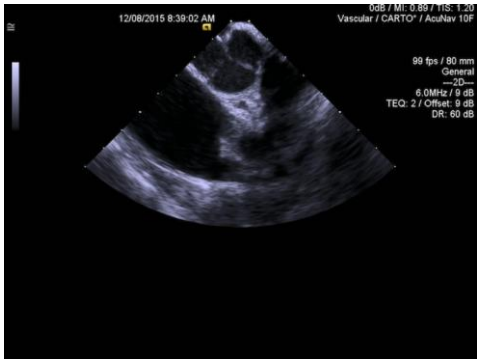
Girard E, Al-Ahmad A. et al. *JACC Imaging 4(3): 259-268, 2011*

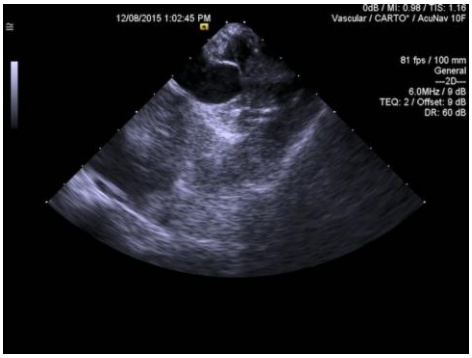
Procedural Imaging

- ICE
  - 2D
  - 3D
- Fluoroscopy registration tools

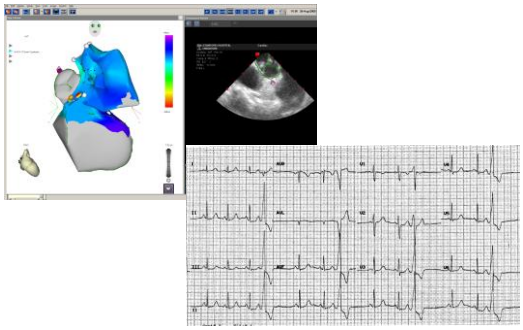
ICE for VT

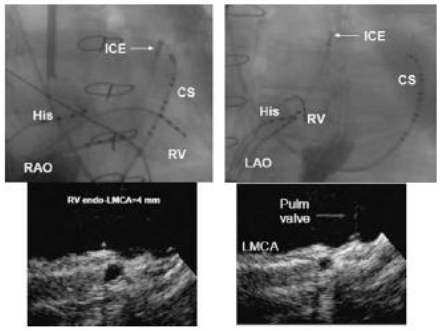
- Placement of the ICE catheter in the RA or RV or pericardium allows visualization of the left ventricle
  - Structures:
    - papillary muscle
    - false tendon
    - valves
    - coronary arteries



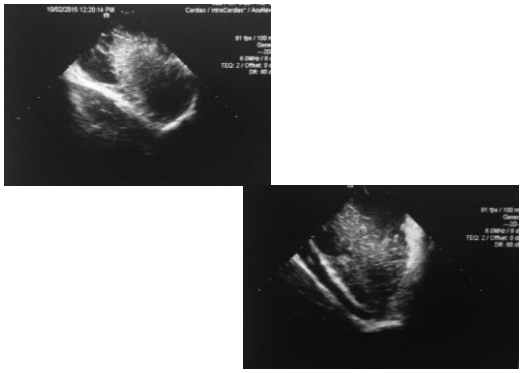


3D Reconstructed Images



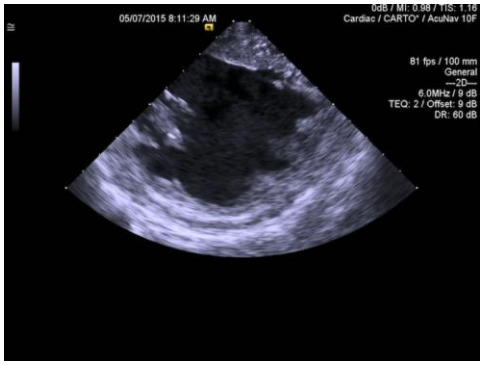


Vaseghi et al, HeartRhythm 2006



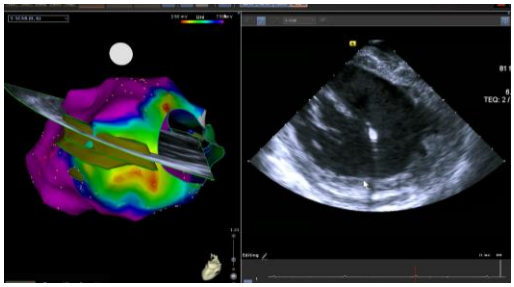
ICE for VT

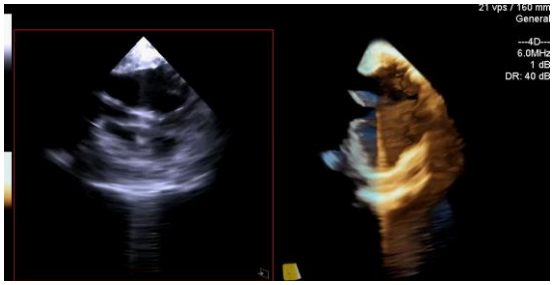
- Visualization of areas of wall thinning or wall motion abnormalities



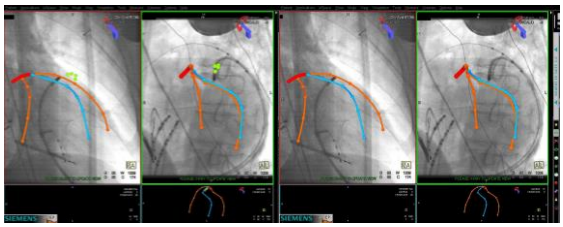
Epicardial Scar

Unipolar voltage ICE Image

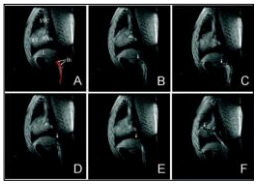


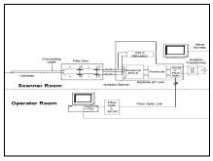


Epicardial VT



Interventional MRI





Real-time guidance of a passive catheter to the His bundle position in the canine model. A, Catheter bipolar electrodes (Bi) are shown in the inferior vena cava. B, The catheter is advanced, with tip (arrow) entering hepatic vein. C, Catheter buckling as a result of advancement into a hepatic vein. D, The catheter tip is withdrawn into the inferior vena cava. E, The catheter tip is advanced beyond the hepatic vein branch in the inferior vena cava. F, The catheter tip is advanced to the tricuspid annulus. SVC indicates superior vena cava; L, liver; RV, right ventricle; and RA, right atrium.

Nazarian S, et al. Circulation. 2008

Conclusions

- Pre-procedural imaging is helpful in gaining insight into stuructural and functional substrate for VT
- CT and MRI correlate well with EA mapping
- Intra-cardiac ultrasound is valuable during VT ablation for identifying substrate, catheter location and preventing complications

Thank You

Epicardial Mapping and Ablation Techniques: How to Prevent and Manage Complications

Mathew D. Hutchinson, MD
Associate Professor of Medicine
University of Pennsylvania

Disclosures

Within the past 12 months, I have received modest financial support from the following entities:

1. Medtronic- lecture honoraria
2. Biosense Webster- advisory panel
3. Abiomed- lecture honoraria

Perioperative considerations

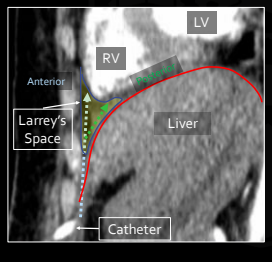
Pericardial access complications

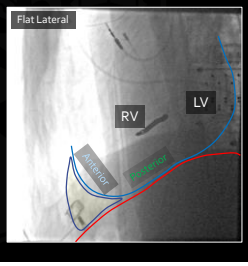
	N	Acute	Chronic
Sacher et al.	156	5.1%	1.9%
Tung et al.	109	8.8%	NR
Della Bella et al.	218	2.3%	1.8%
Piers et al.	29	7%	3%

Sacher et al. J Am Coll Cardiol 2010;55:2366-72
Tung et al. Heart Rhythm 2013;10:490-498
Della Bella et al. Circ Arrhythm Electrophysiol 2011;4:653-9
Piers et al. Circ Arrhythm Electrophysiol 2013;6:513-521

- Patient selection
  - Habitus
  - Prior surgery, pericarditis
- Hematologic issues
  - Anticoagulation management
  - Blood products
- Equipment
  - Access-related
  - Coronary angiography
  - Phrenic protection
- Surgical backup

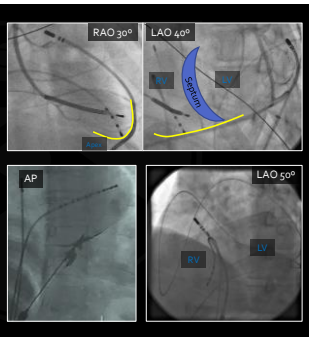
Anatomy of the approach





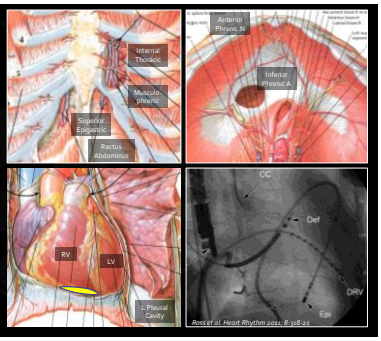
Tricks and tips

1. Needle techniques
2. Define cardiac border
3. Use ICE, contrast
4. Don't panic with RV perf
5. Confirm guidewire position
6. Maintain sheath hygiene

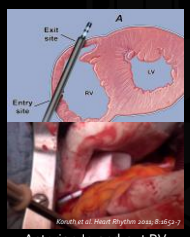


Access-related complications

- Superficial vessels
- Abdominal viscera
- Cardiac chambers
- Epicardial vessels



Approach-specific complications

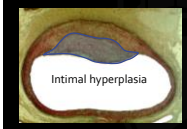


Kovoth et al. Heart Rhythm 2011; 8:1652-7

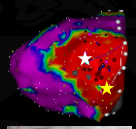
Anterior: In-and-out RV perforation

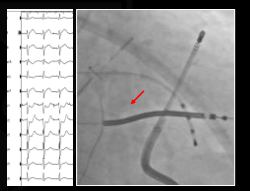
Posterior: Liver laceration

Ablation-related coronary injury



- Presentation
  - Acute occlusion, spasm
  - Chronic stenosis
- Likelihood of vessel injury:
  - Proximity to vessel (<2mm)
  - Internal diameter (<1.8mm)
  - Energy source (RF>cryo)

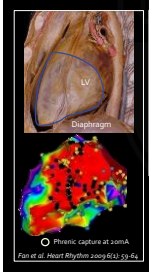




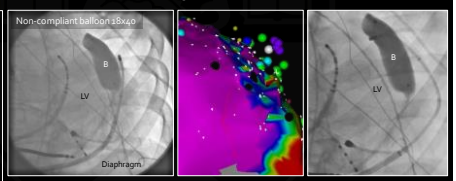
Hypotension during RF

D'Avila et al. PACE 2002; 25:1488-92
Lustgarten et al. Heart Rhythm 2005; 2:82-90

Phrenic nerve protection



Fan et al. Heart Rhythm 2009;6(1):59-64



- Double pericardial access required
- Consider steerable sheath
- Position ablator between LV and balloon
- Alternative air +/- fluid- increased DFT

Re-access after pericarditis/cardiac surgery

- 28 pts; 4-9% total epi procedures
- Acute success 17/28
- 100% with adhesions (anterior post surgical)
- Blunt dissection required for mapping; deflectable sheath
- Complications: ~10% (no deaths)

Sosa et al. J Interv Card Electr 2004; 10:281-288
Roberts-Thompson et al. J Cardiovasc Electrophysiol 2010; 21:406-411
Tschabrunn et al. Heart Rhythm 2013; 10:265-269

Summary- Epi access complications

- Relatively high complication rate
- Adequate planning and equipment is essential to success
- Complications specific to timing and approach
- Develop a specific technique, but modify it as required

Thank You!