



Brigham and Women's Hospital

Founding Member, Mass General Brigham

Bradycardias, Syncope, and Sudden Death Prevention

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- Harvard Medical School
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- Associate Professor of Medicine@ HMS
- Clinical focus: Cardiac Electrophysiology
- Research focus: Ventricular Tachycardia



Disclosures

- All concluded in the last 24 months

Objectives

- Review physiology, pathophysiology and evaluation of bradycardia
- Discuss permanent pacing indications and novel pacing techniques
- Review pacing to treat heart failure
- Discuss epidemiology and evaluation of sudden cardiac death
- Review defibrillator indications

Bradycardia Examples

Sinus Bradycardia



Mobitz I Block



Mobitz II Block

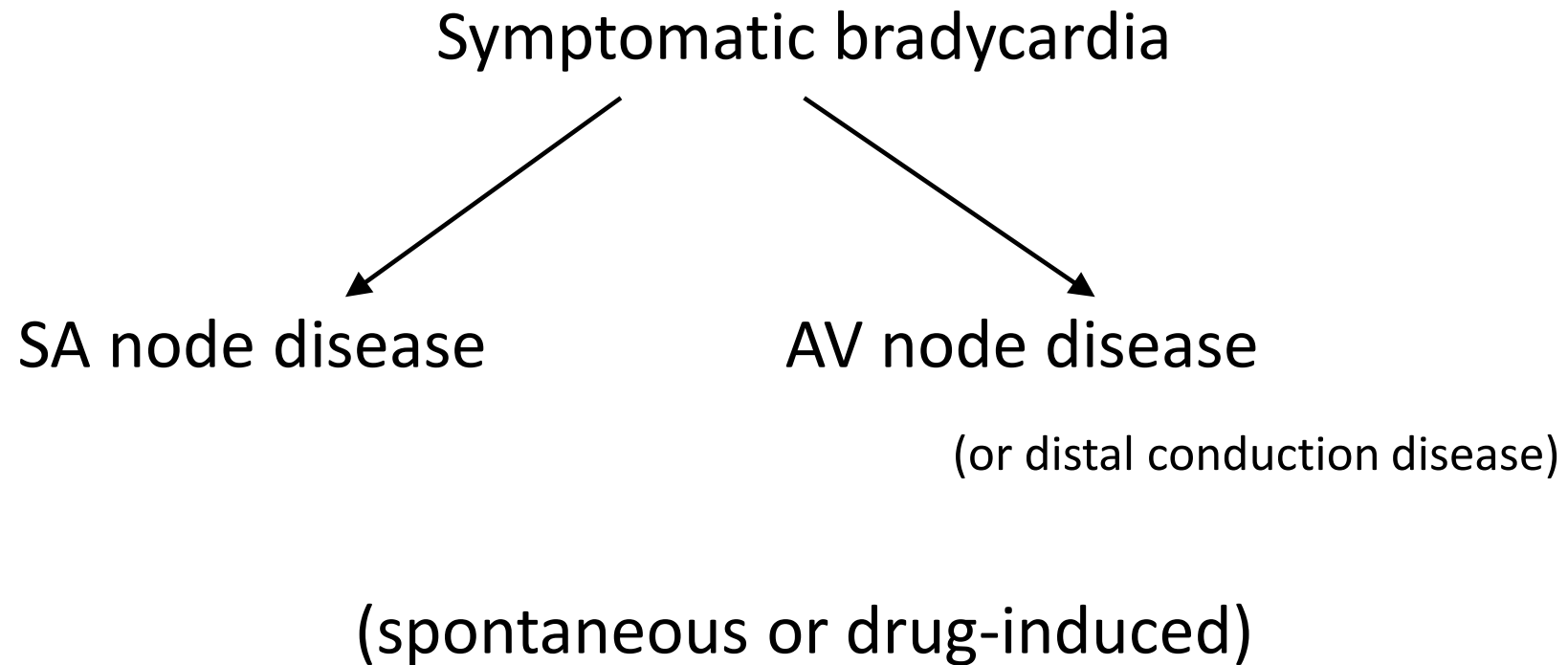


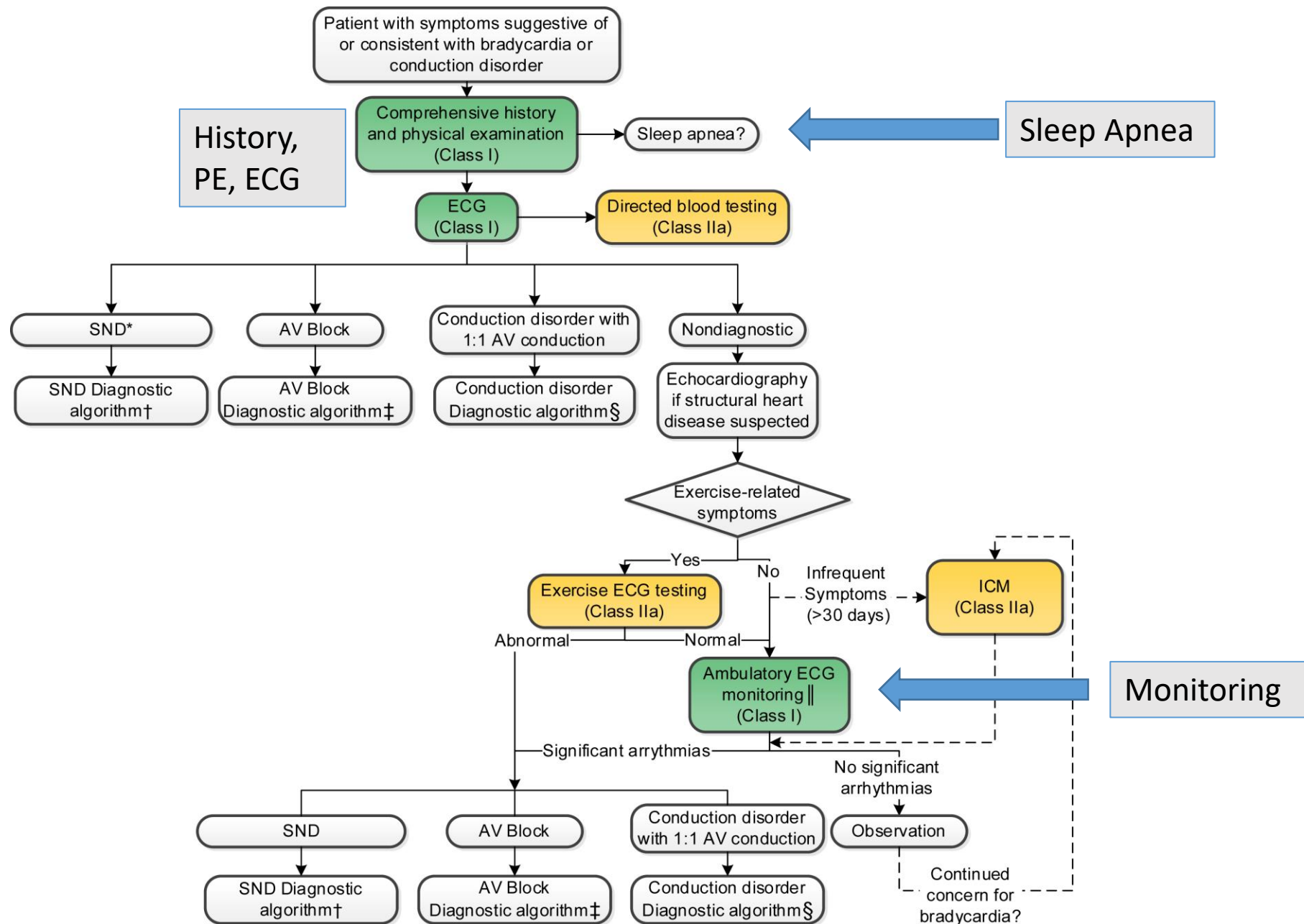
Complete Heart Block



- Indicative of conduction disease **below** the AV node
- Needs urgent temporary (and then permanent) pacing

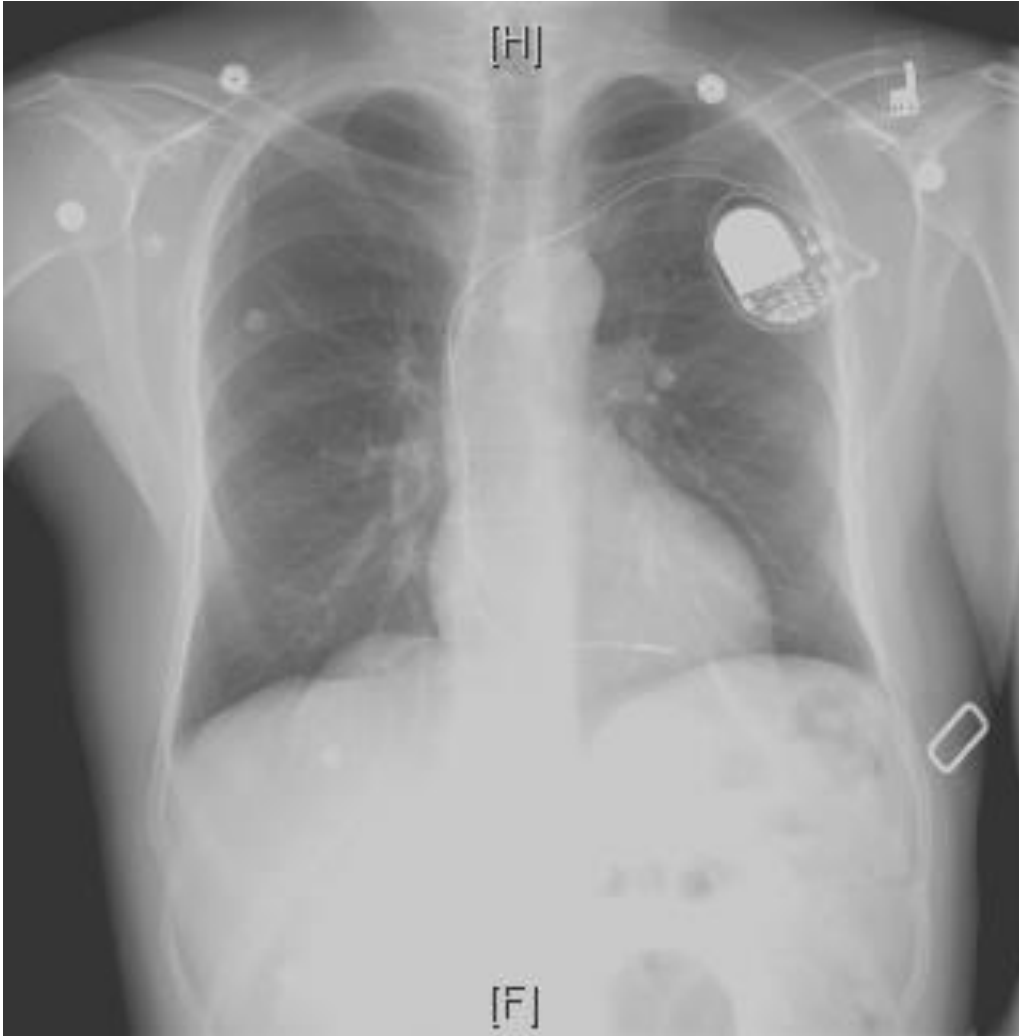
Indications for Pacing





Type of Monitor	Device Selection	Patient Selection
Nonphysician prescribed smartphone-based systems	Convenient real time recordings of symptomatic events	Patient must financially be able to access, not best for sudden incapacitating symptoms
Holter monitor	24-48 hours of Monitoring	Rarer events not detected, no real time information
Patient-activated TTM (Event Monitor)	Real time recordings of symptomatic events	not best for sudden incapacitating symptoms
External Loop Recorder (Patient or Auto Triggered)	Real time recordings of symptomatic events with pre-symptomatic recording	Less convenient, much be worn at all times. Less good monitoring of asymptomatic arrhythmias
Patch Monitor	Continuously records with patient-trigger capability	More convenient size and functionality. Real time and non real time models
Implantable Loop Recorder	Surgically implanted	Rare but serious sudden events

What do pacemakers do?

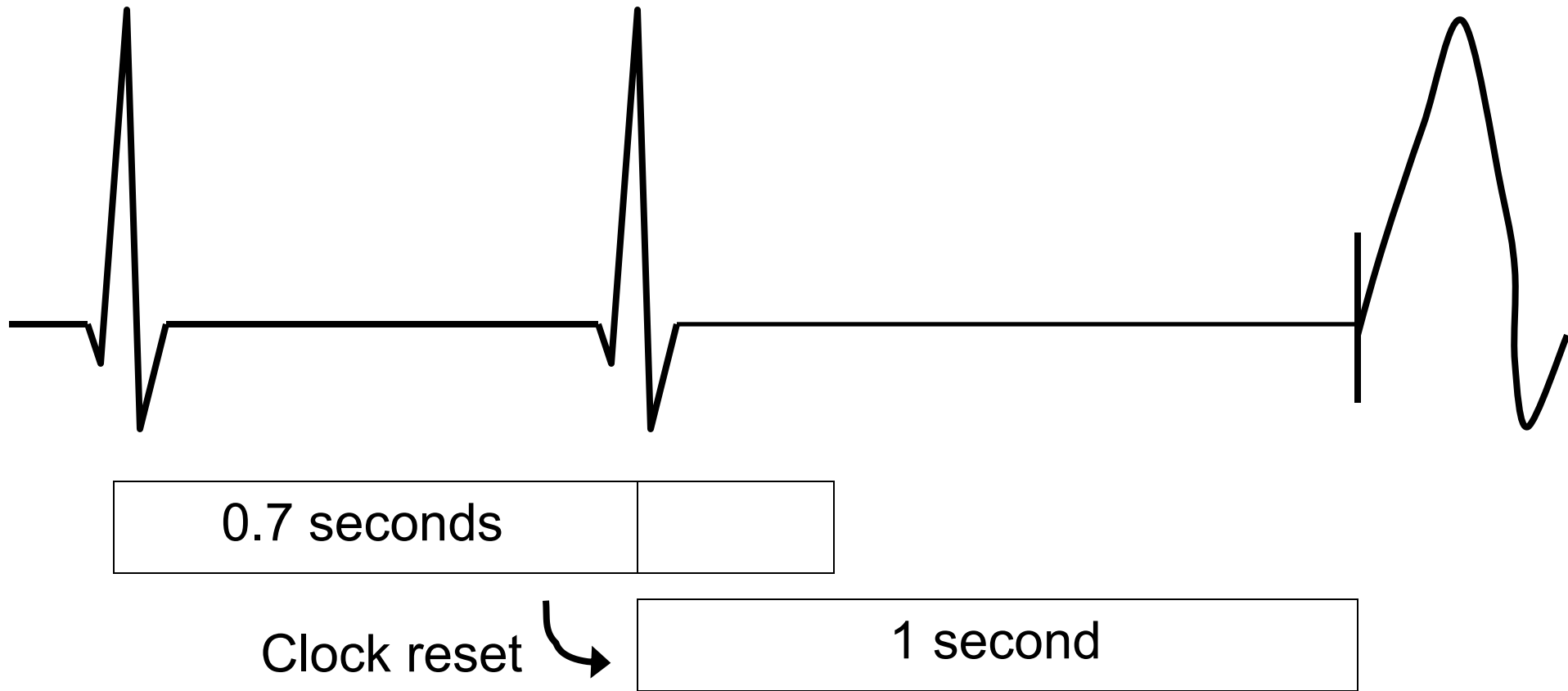


- Electronic pacemakers deliver electrical impulses that depolarize the myocardial cells near the lead tip, such that the signal propagates into the contiguous myocardium
- Pulses can be delivered in many ways, depending on how the pacemaker is programmed

Types of Pacemakers

- Single lead in the right atrium or right ventricle
- Leads in both RA and RV
- Leads pacing RV, LV = biventricular pacer or cardiac resynchronization therapy
- Conduction system pacing
 - His bundle pacing
 - Left bundle (area) pacing

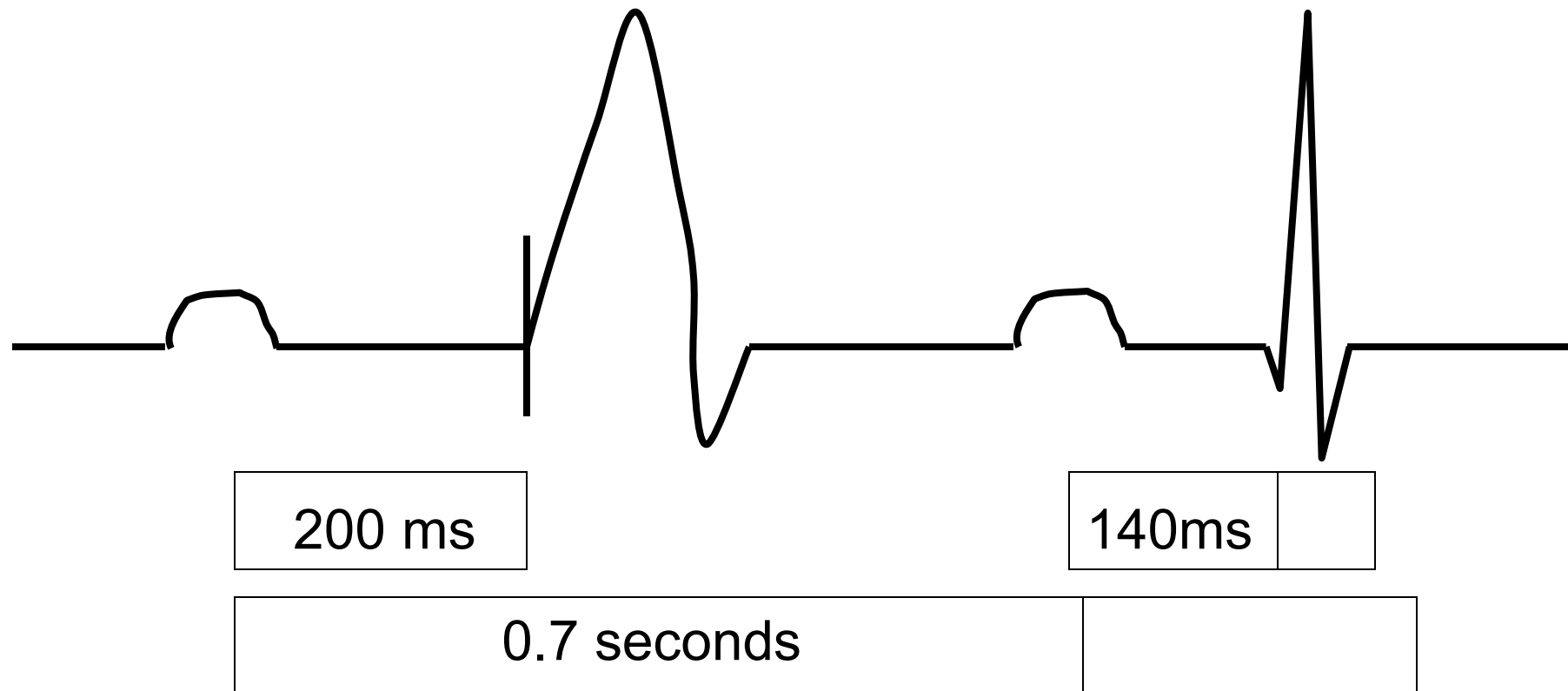
A VVI Pacemaker Is A Clock (that resets)



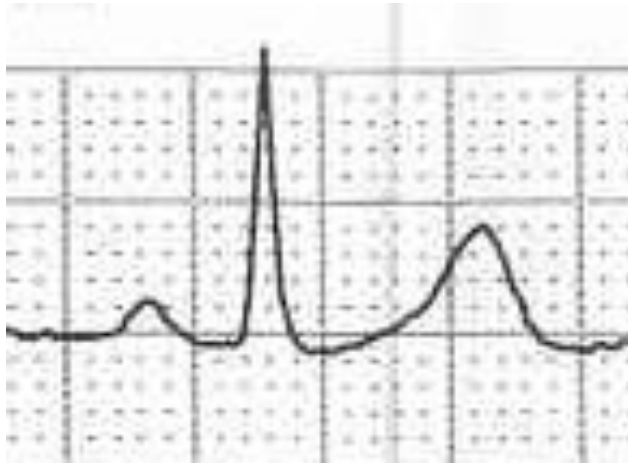
A DDD Pacemaker is 2 Clocks

DDD at 60 ppm = rate clock

AV delay 200ms = PR interval clock



AS VS



AS VP



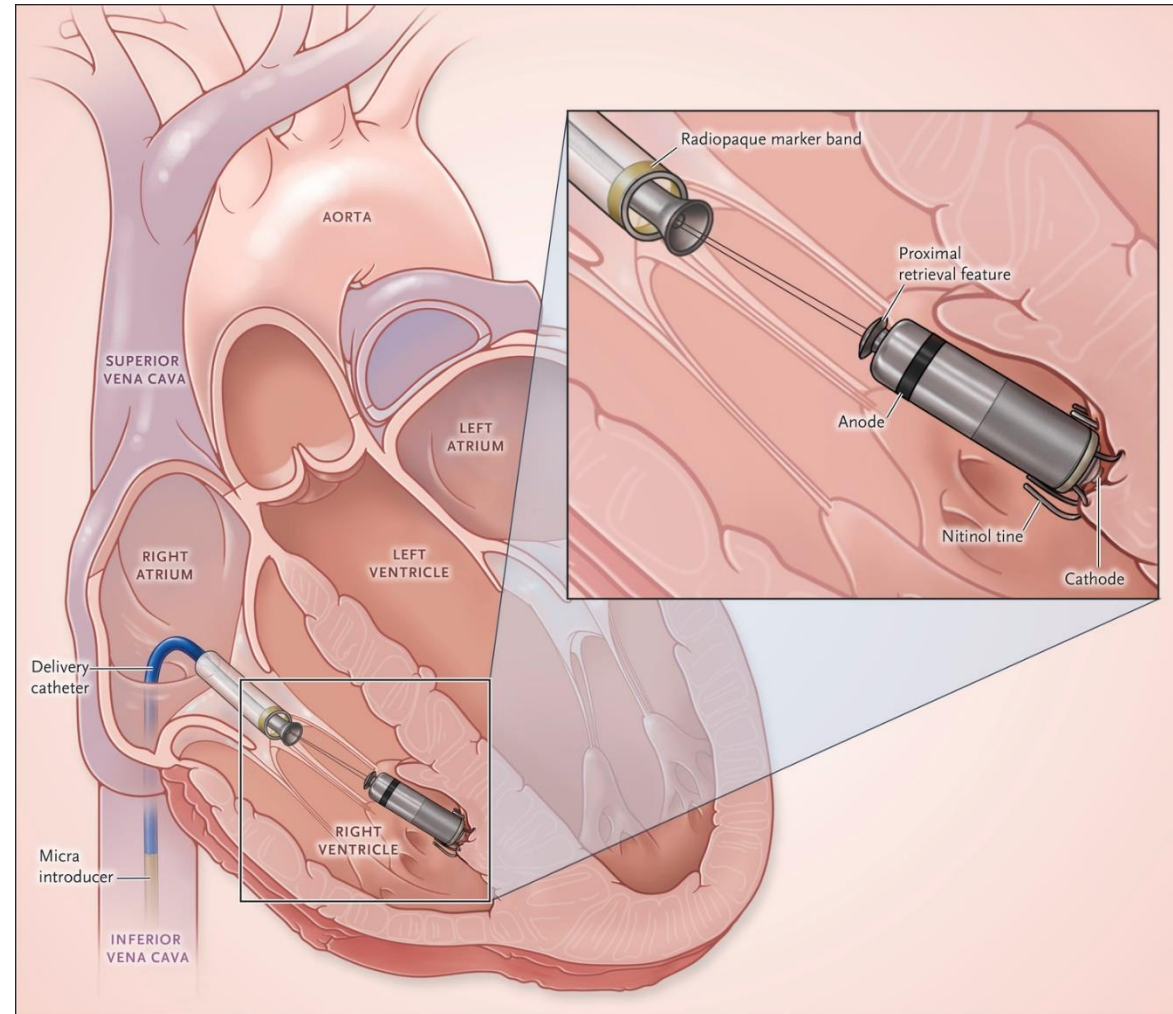
AP VS

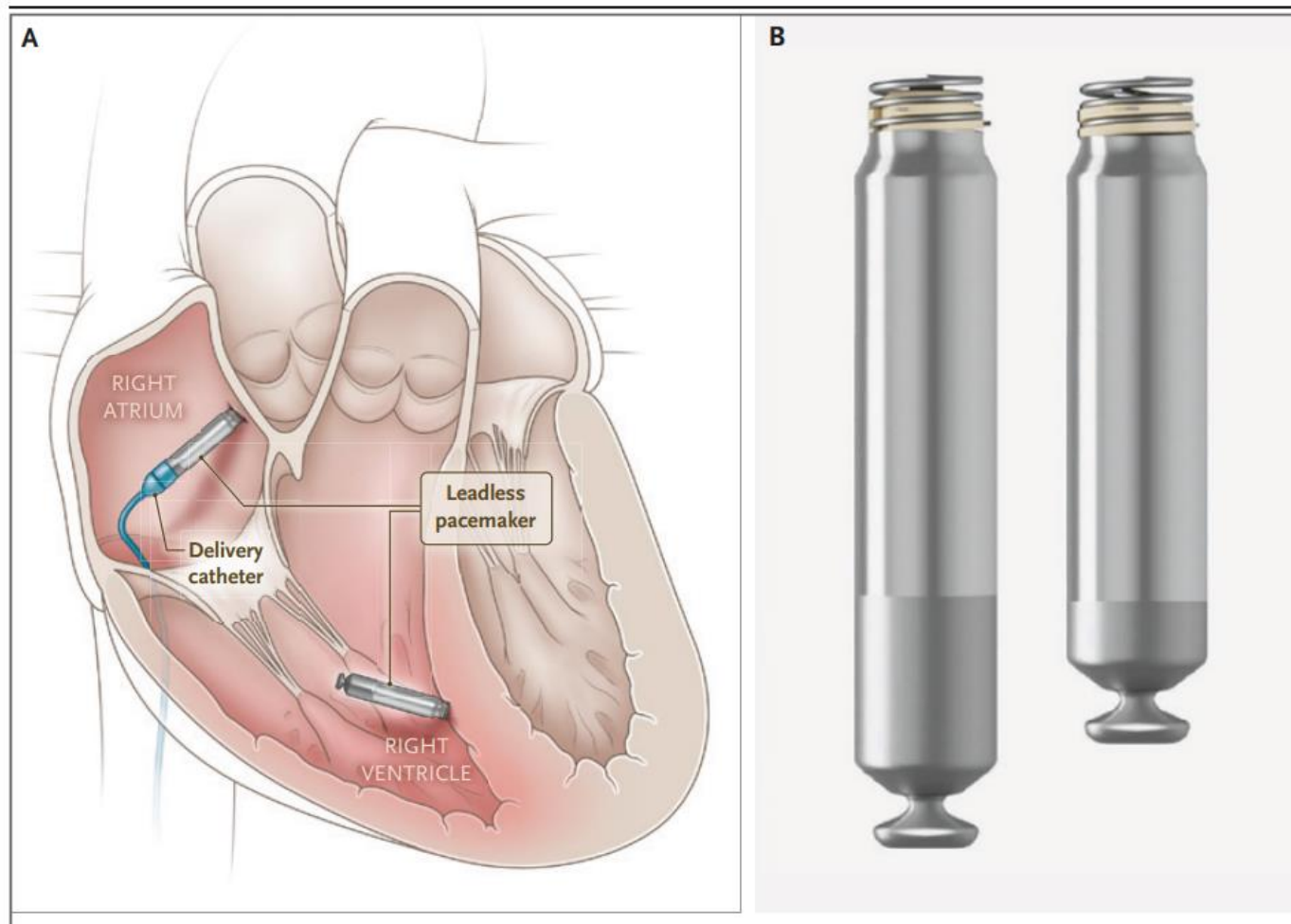


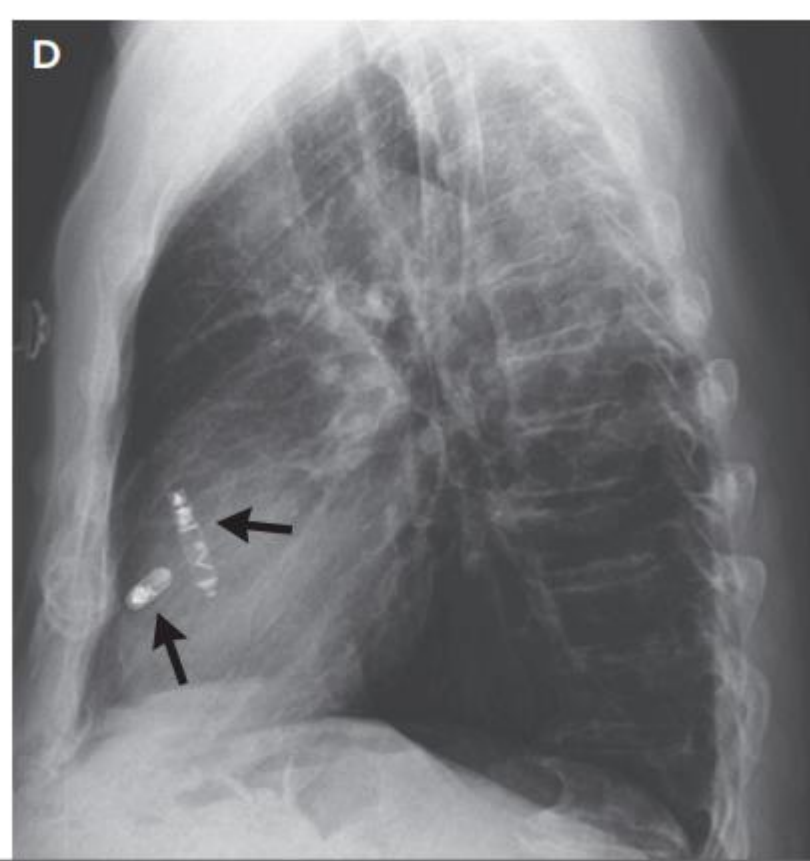
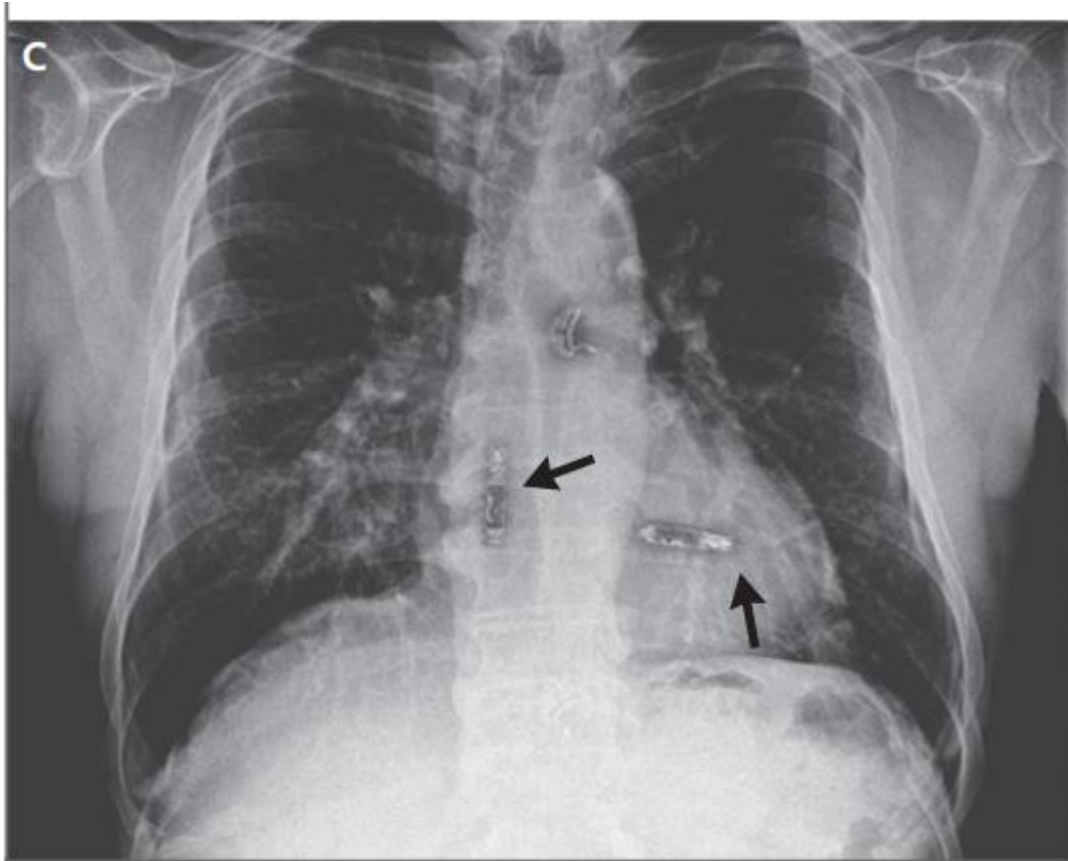
AP VP



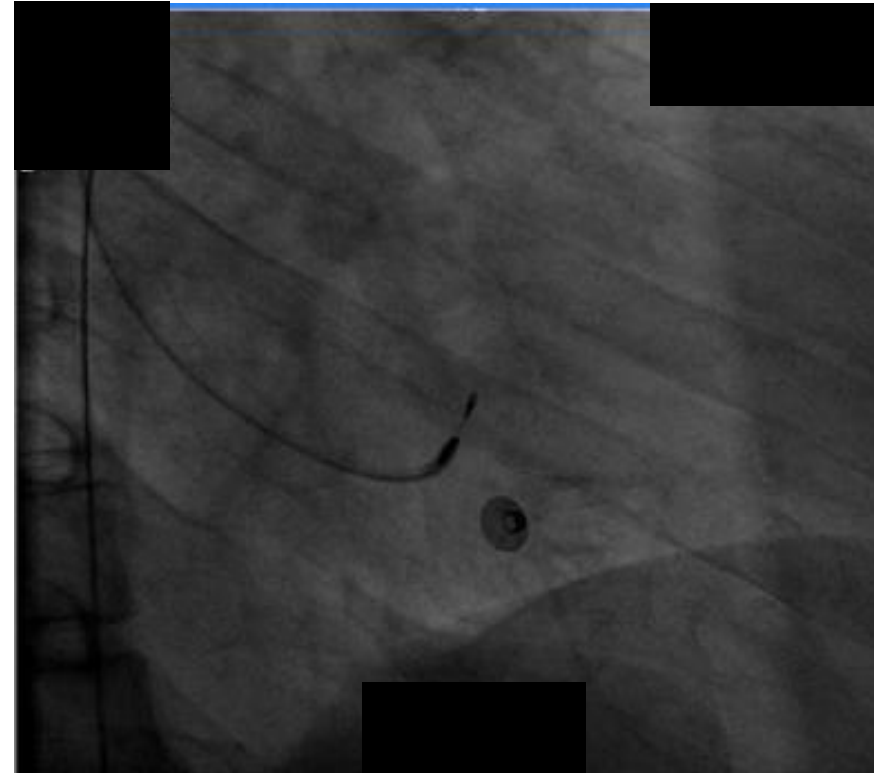
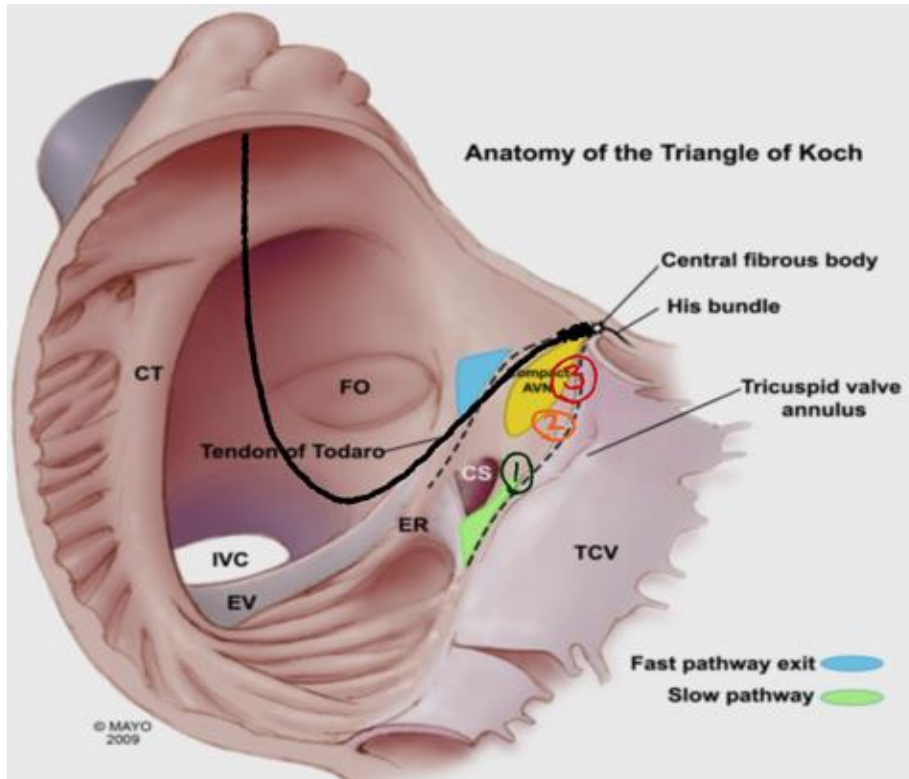
Leadless pacing: Transcatheter Pacing System Positioned in the Right Ventricle.



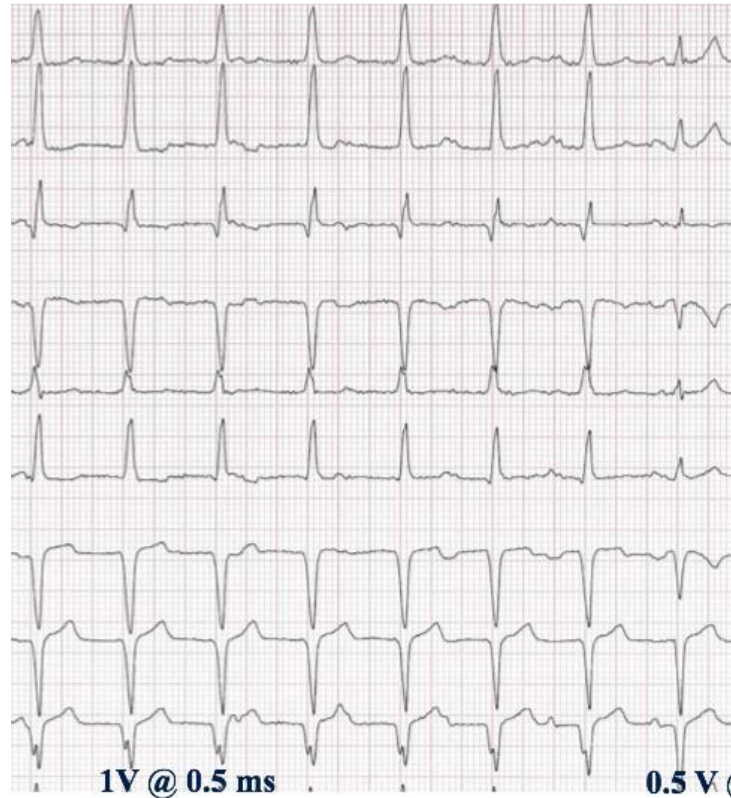




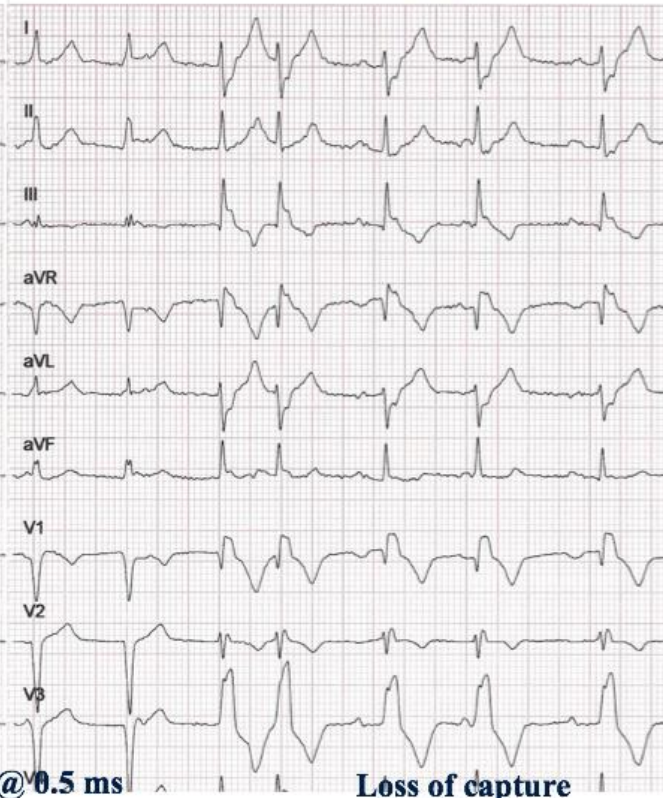
His Bundle Pacing: Anatomy



Nonselective HBP



Selective HBP



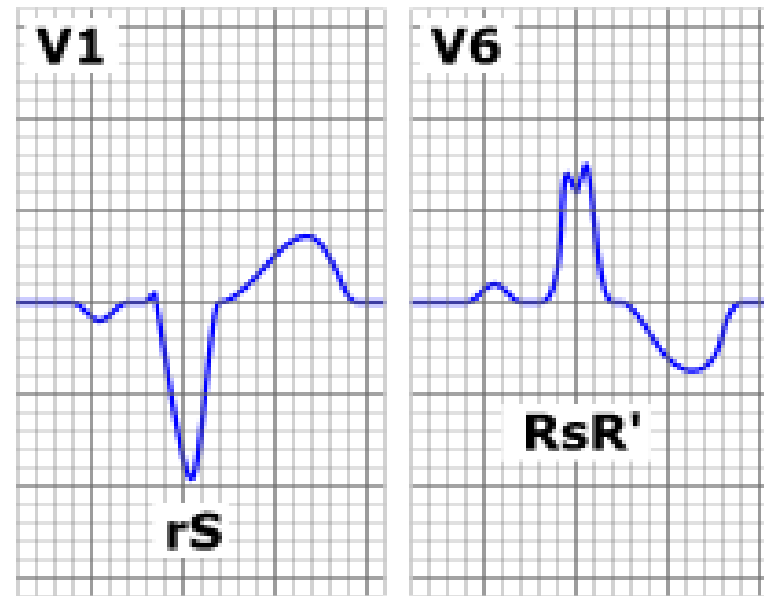
Underlying RBBB

Loss of capture

Main Consequences of LBBB

- Widening of QRS complex (>120 msec)
- Increased time to complete ventricular contraction
- Septal activation much before free wall of ventricle, leading to discoordinated contraction and wasted energy
- Mitral valve may leak as a result of sequential activation of papillary muscles

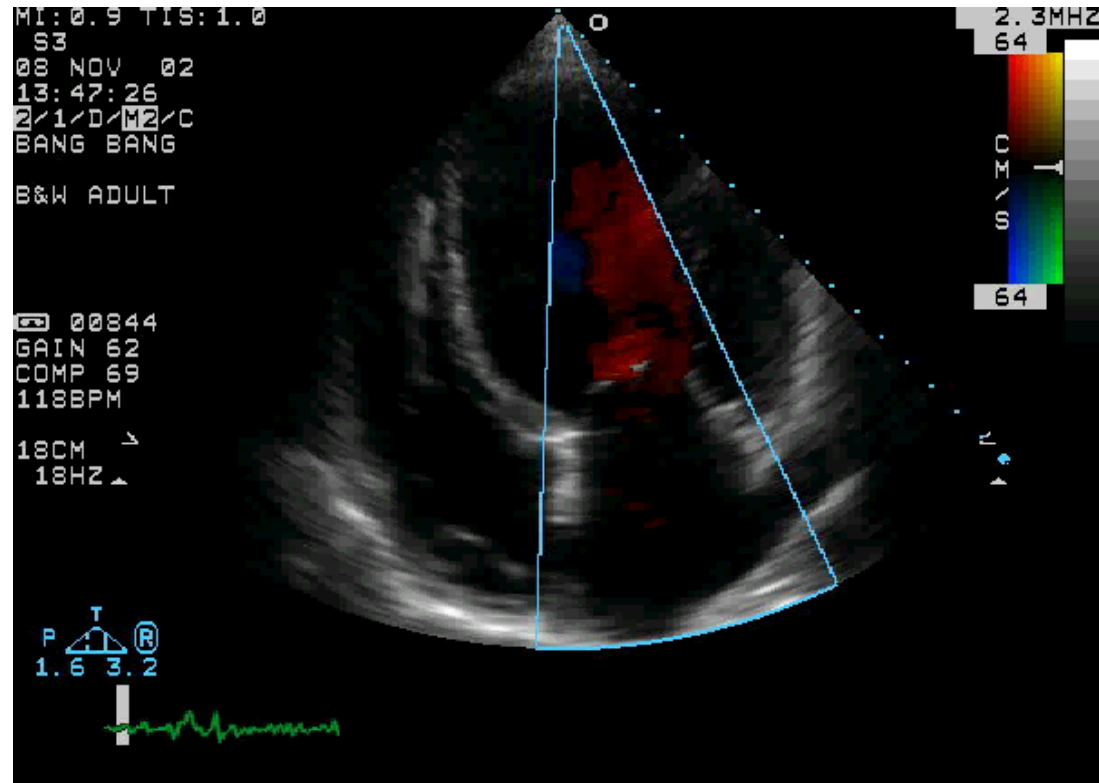
Left bundle branch block characteristics



Deleterious Effects of Ventricular Dyssynchrony on Cardiac Function

Reduced diastolic filling time ¹

- + Weakened contractility ²
 - + Protracted mitral regurgitation ²
 - + Post systolic regional contraction ³
- = Diminished stroke volume



1. Grines CL, et al *Circulation* 1989;79: 845-853

2. Xiao HB, et al *Br Heart J* 1991;66: 443-447

3. Sogaard P, et al. *J Am Coll Cardiol* 2002;40:723-730

Achieving Cardiac Resynchronization

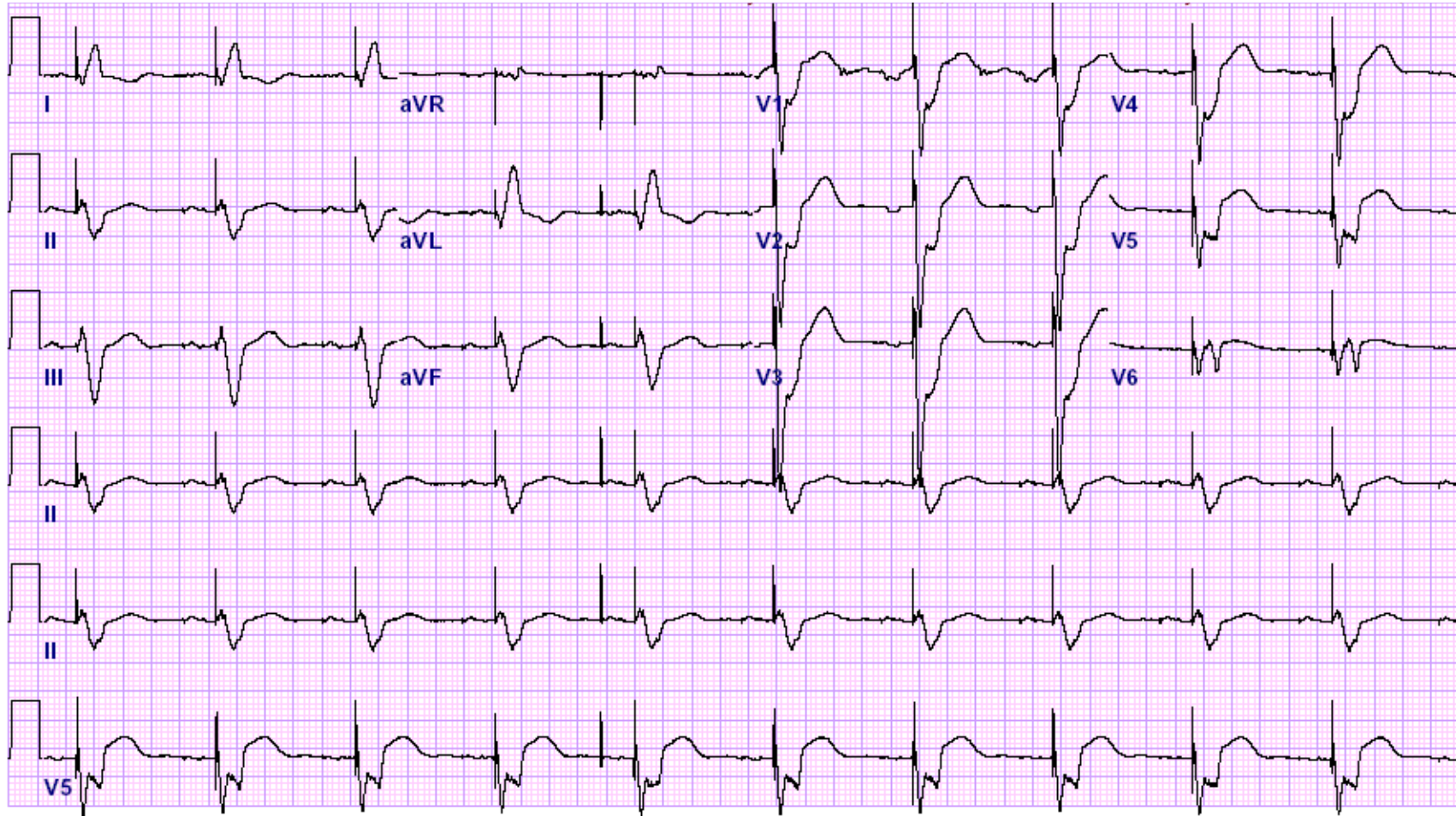
Goal: Pace Right and Left Ventricles

- Epicardial Approach
 - Requires thoracotomy
- Transvenous Approach
 - Requires access to the coronary sinus
 - Requires leads developed for LV application

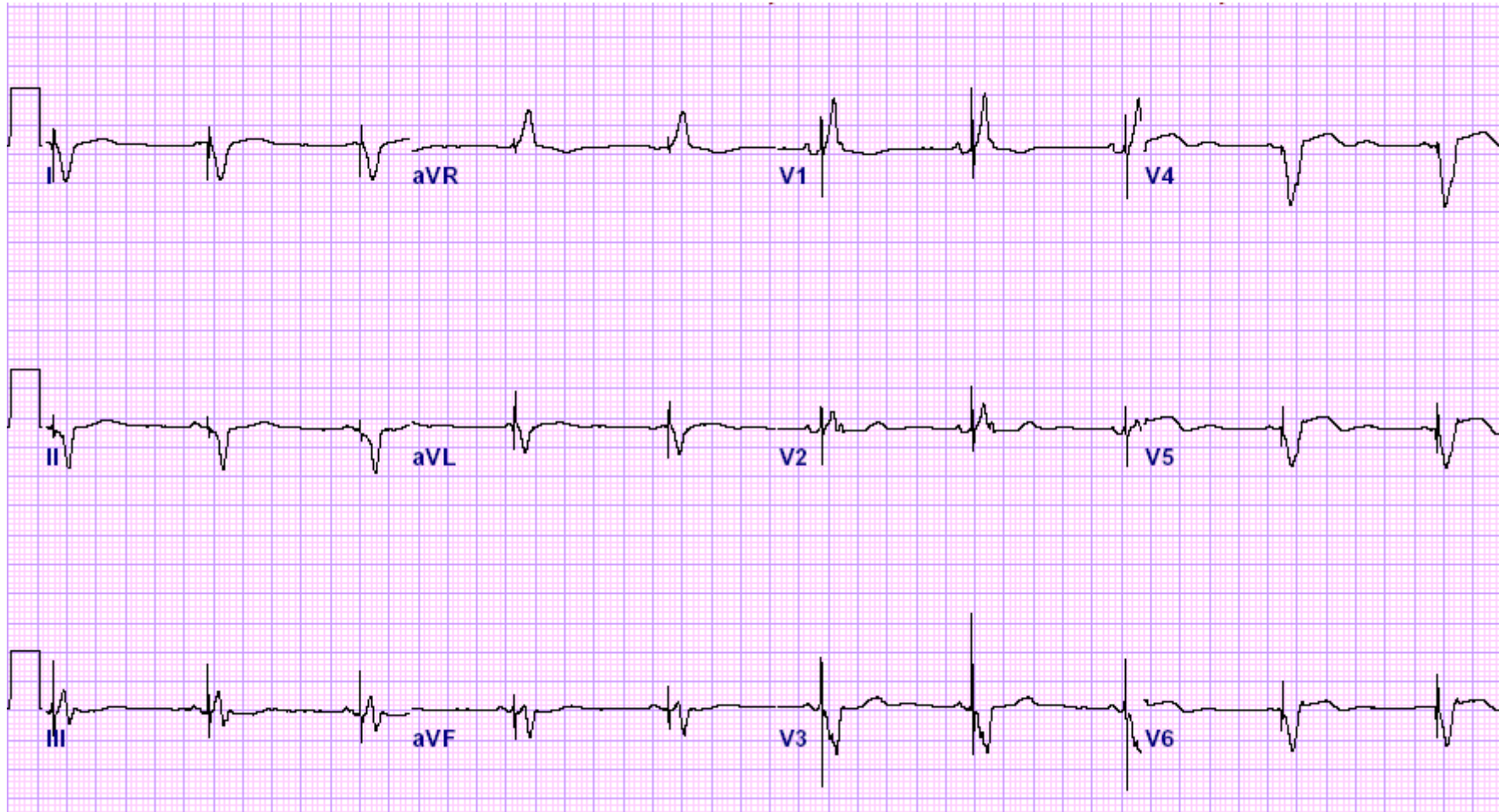


1. Bakker et al. *J of Cardiac Failure* 1998; 4[3]:1-35
2. Saxon et al. *PACE* 1998; 21 Part II: 914
3. Daubert et al. *PACE* 1997; 20[II]
4. Gras et al. *PACE* 1998; 21[II]:824

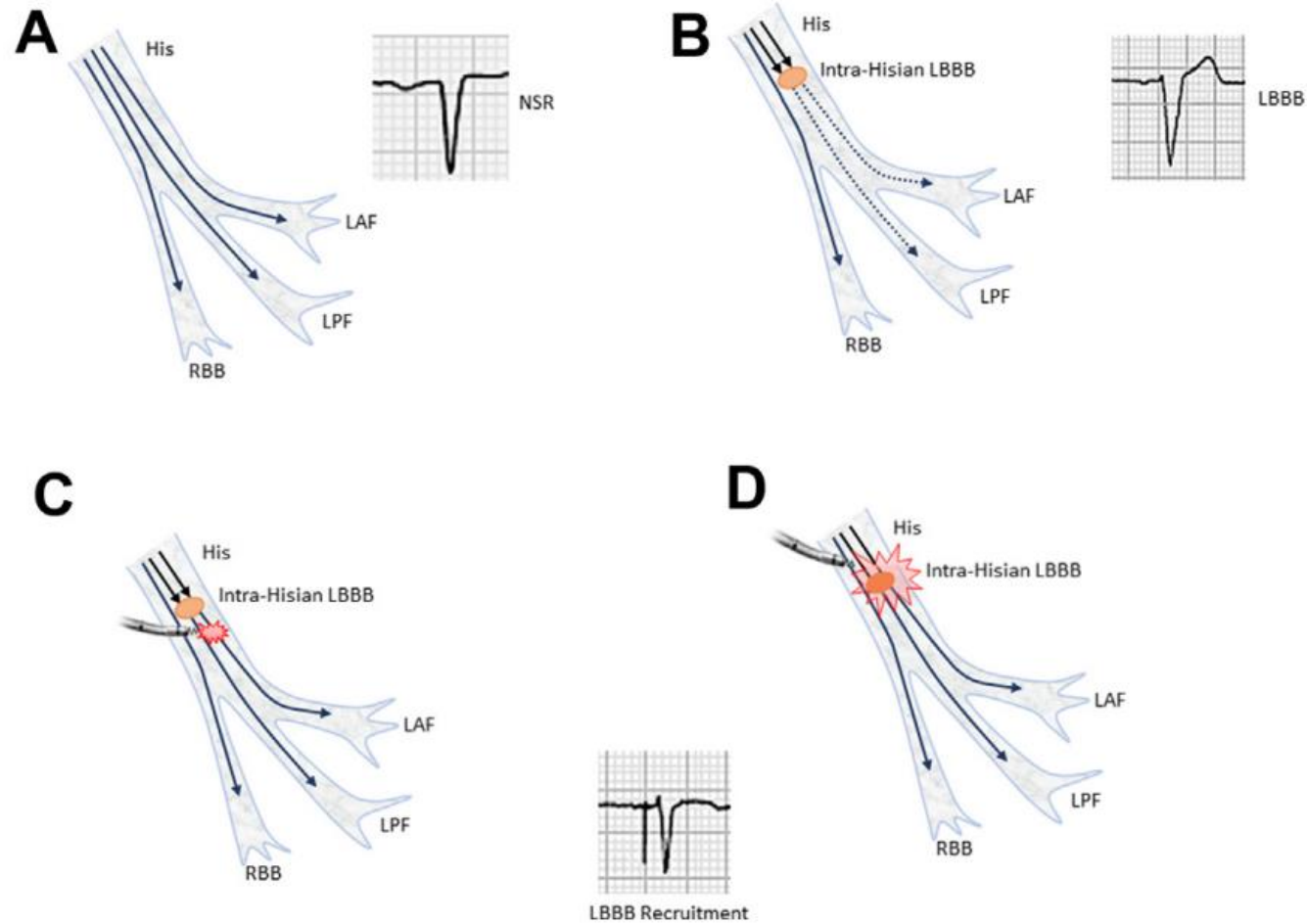
Pre-op EKG: QRS 216 msec



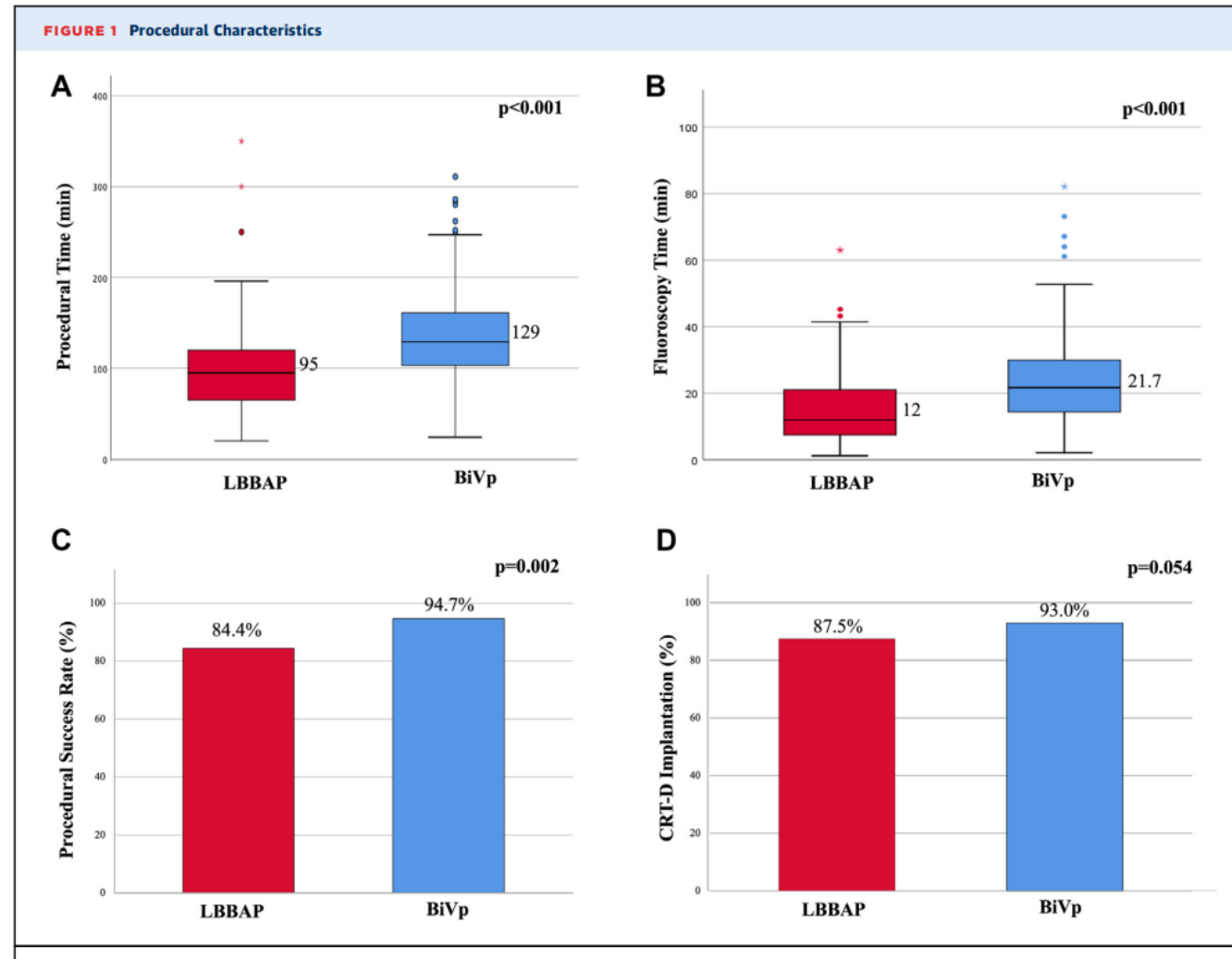
Post-op EKG: QRS 152 msec



Left bundle recruitment during septal pacing



Preliminary Observational Series Suggest Outcomes Similar to Biventricular Pacing

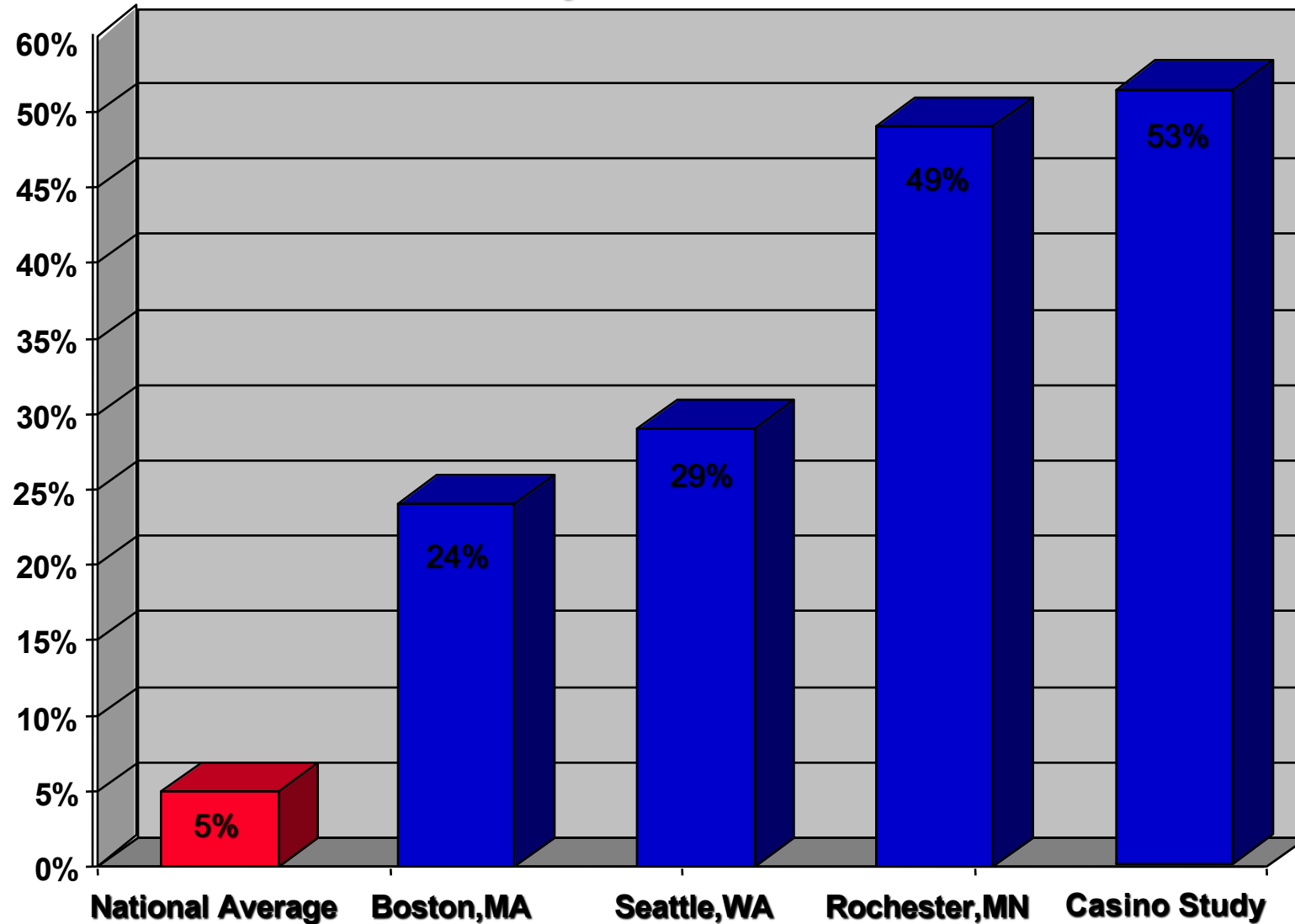


Sudden Cardiac Arrest

- >400,000 out-of-hospital cardiac arrests per year in U.S.
- ~50% of these arrests are in patients having a myocardial infarction
- 95% out-of-hospital mortality
- Goals:
 - Prevention
 - Recognition of high risk populations



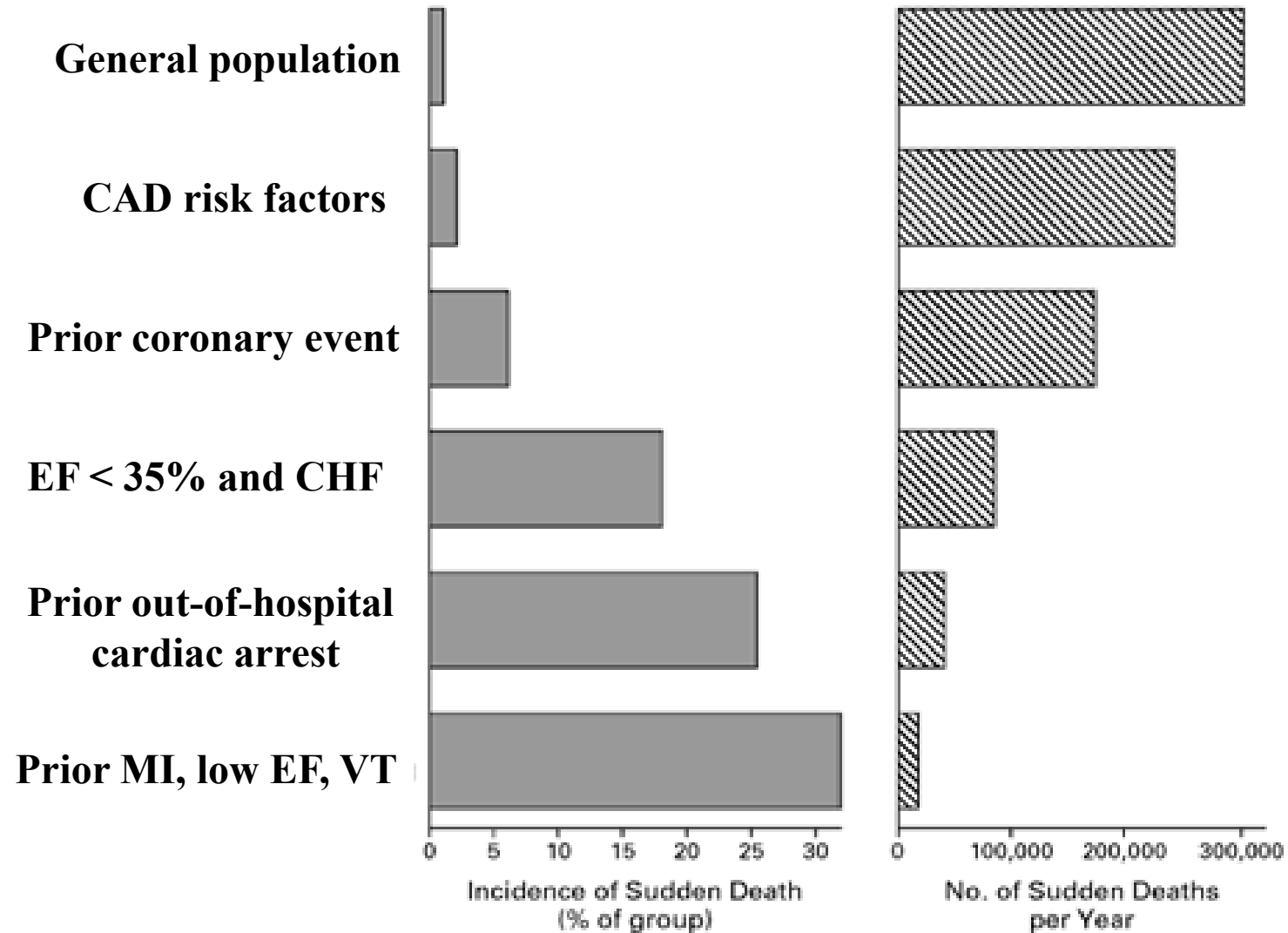
AEDs Improve Survival



White RD. Ann Emer Med. 96;28:480-485.
Smith SC. Circ. 97;13:1321-1324.

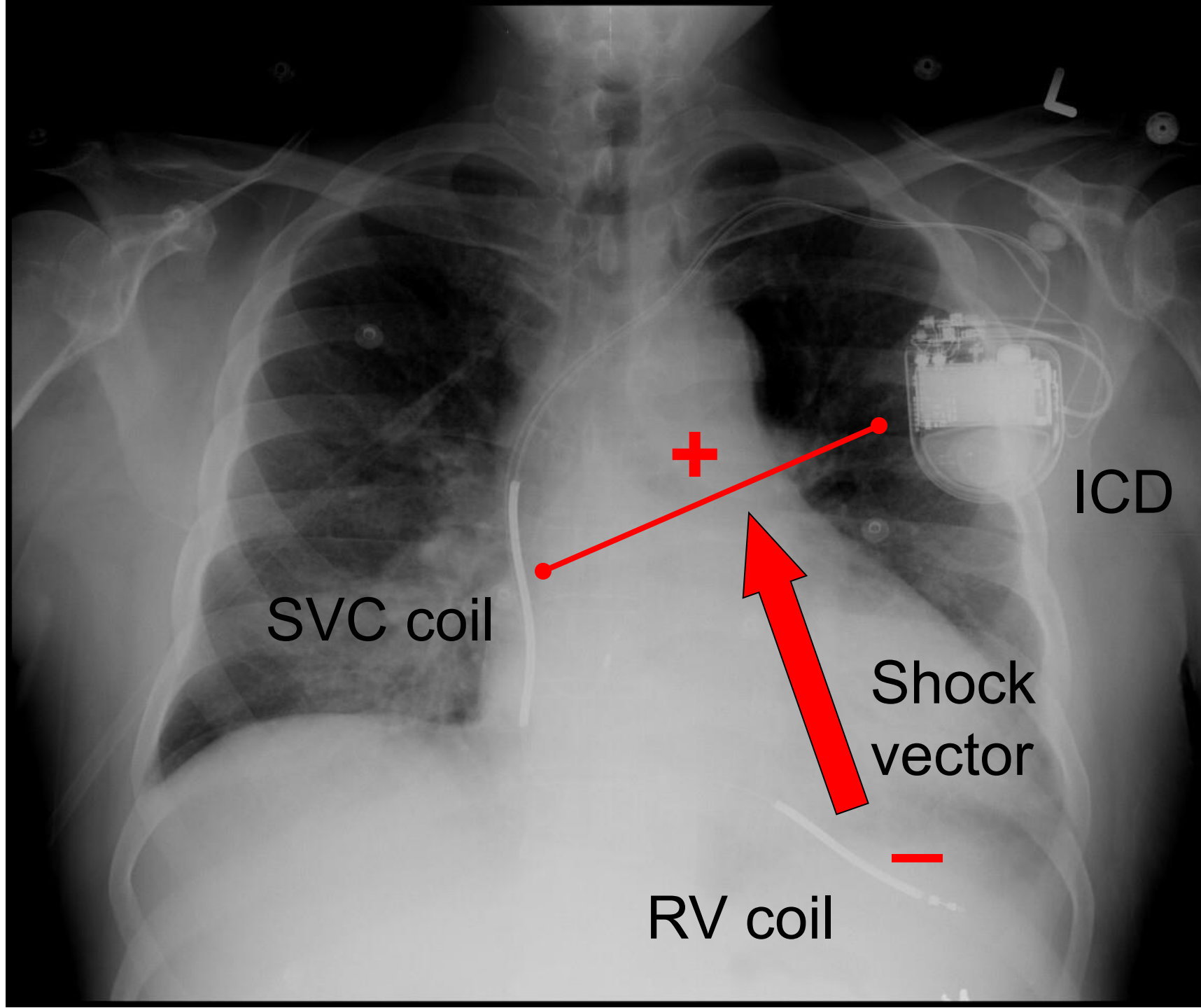
Cobb LA. Circ. 92;85:198-102.
Valenzuela TD. N Engl J Med. 2000;343:1206-1209.

Patients at risk for sudden cardiac death

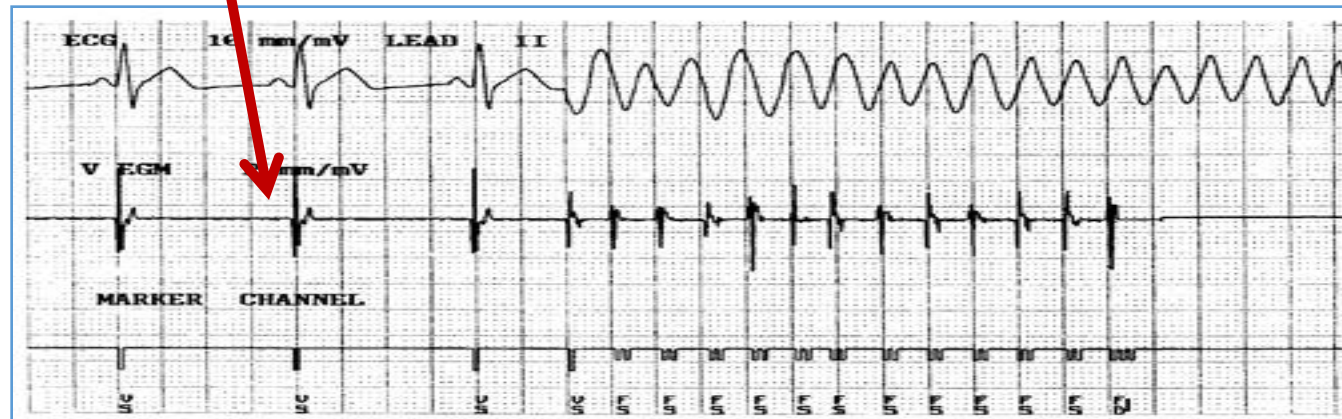
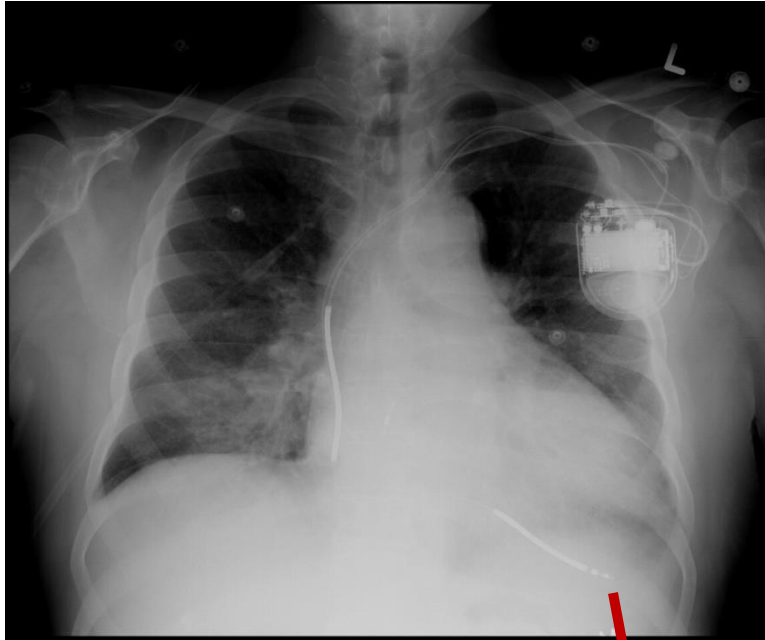


Evaluation after Arrest

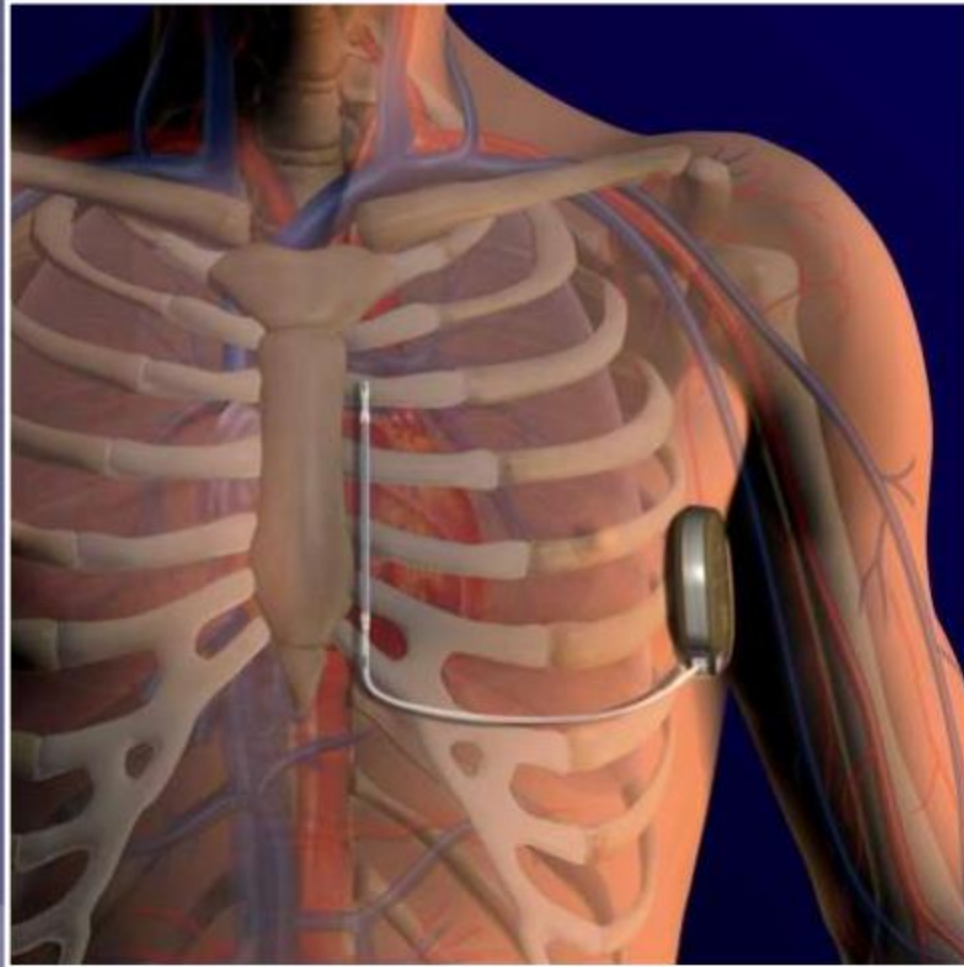
- Evaluate for acute causes
 - Myocardial ischemia/infarction
 - Electrolytes
 - Drugs
 - Inflammatory heart disease
- Characterize underlying heart disease
 - **Echocardiogram**
 - LV or RV dysfunction, areas of infarct or scar
 - **Coronary angiography / Cardiac CT / Exercise testing**
 - **Consider cardiac MRI**
 - **Consider EP Study**
 - **If no reversible cause or contraindication, likely Implantable Cardioverter Defibrillator implant**



How does it know what to shock?



Subcutaneous ICD



Device Settings

Therapy: ON

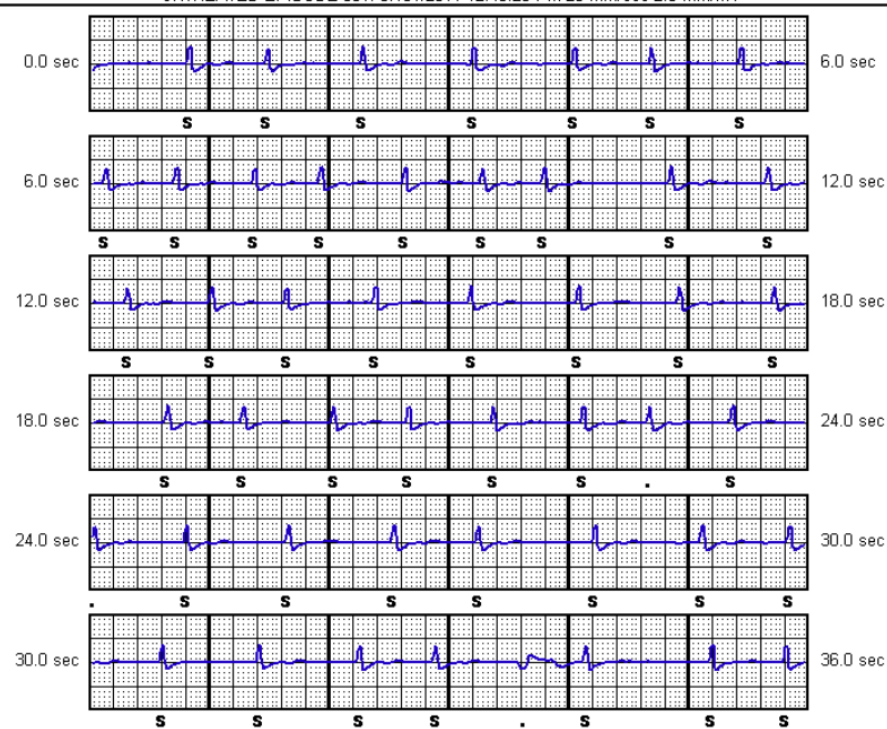
Shock Zone: 240 bpm
Conditional Shock Zone: 180 bpm
Post Shock Pacing: ON



Gain Setting: 1X
Sensing Configuration: Secondary

S = Sense
P = Pace
H = Noise
T = Tachy Detection
C = Charge Start
· = Discard
⚡ = Shock
⏏ = Episode End

UNTREATED EPISODE 001: 07/31/2011 12:43:28 PM 25 mm/sec 2.5 mm/mV

**Device Settings**

Therapy: ON

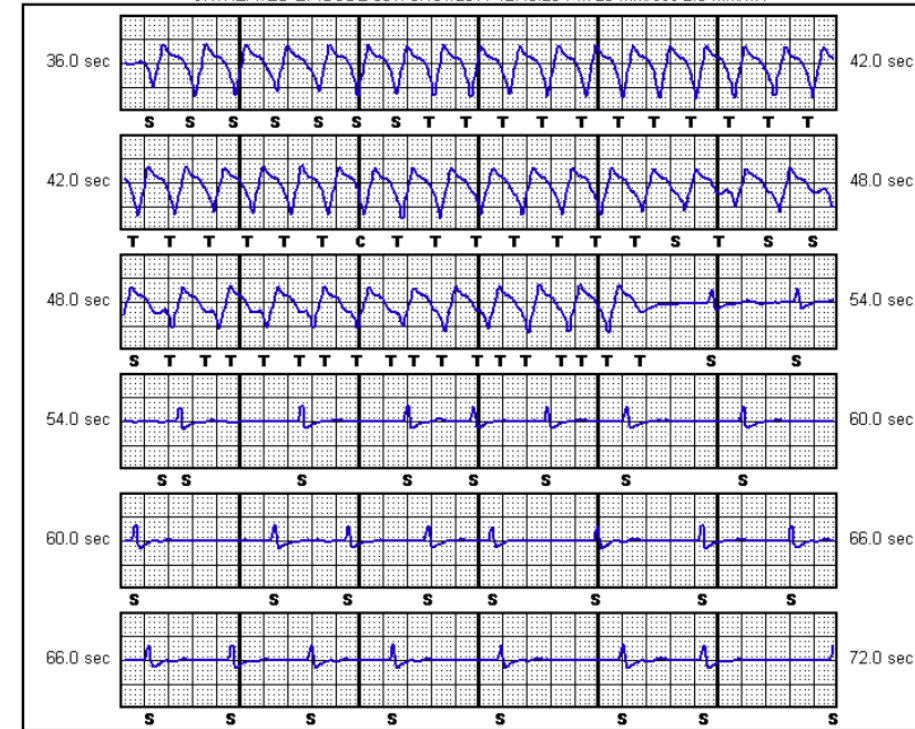
Shock Zone: 240 bpm
Conditional Shock Zone: 180 bpm
Post Shock Pacing: ON



Gain Setting: 1X
Sensing Configuration: Secondary

S = Sense
P = Pace
H = Noise
T = Tachy Detection
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⚡ = Shock
⏏ = Episode End

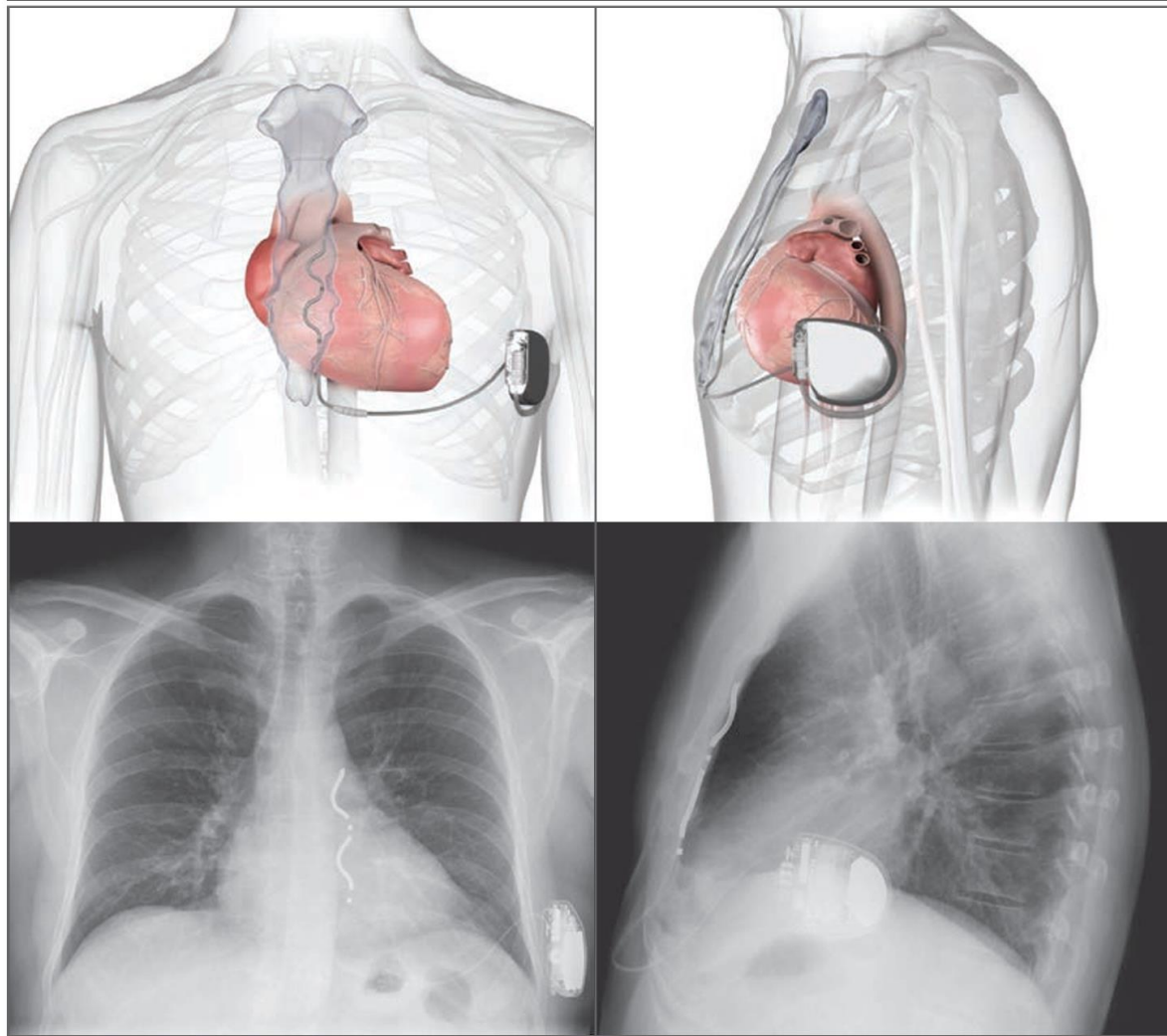
UNTREATED EPISODE 001: 07/31/2011 12:43:28 PM 25 mm/sec 2.5 mm/mV



CE Mark Approved.

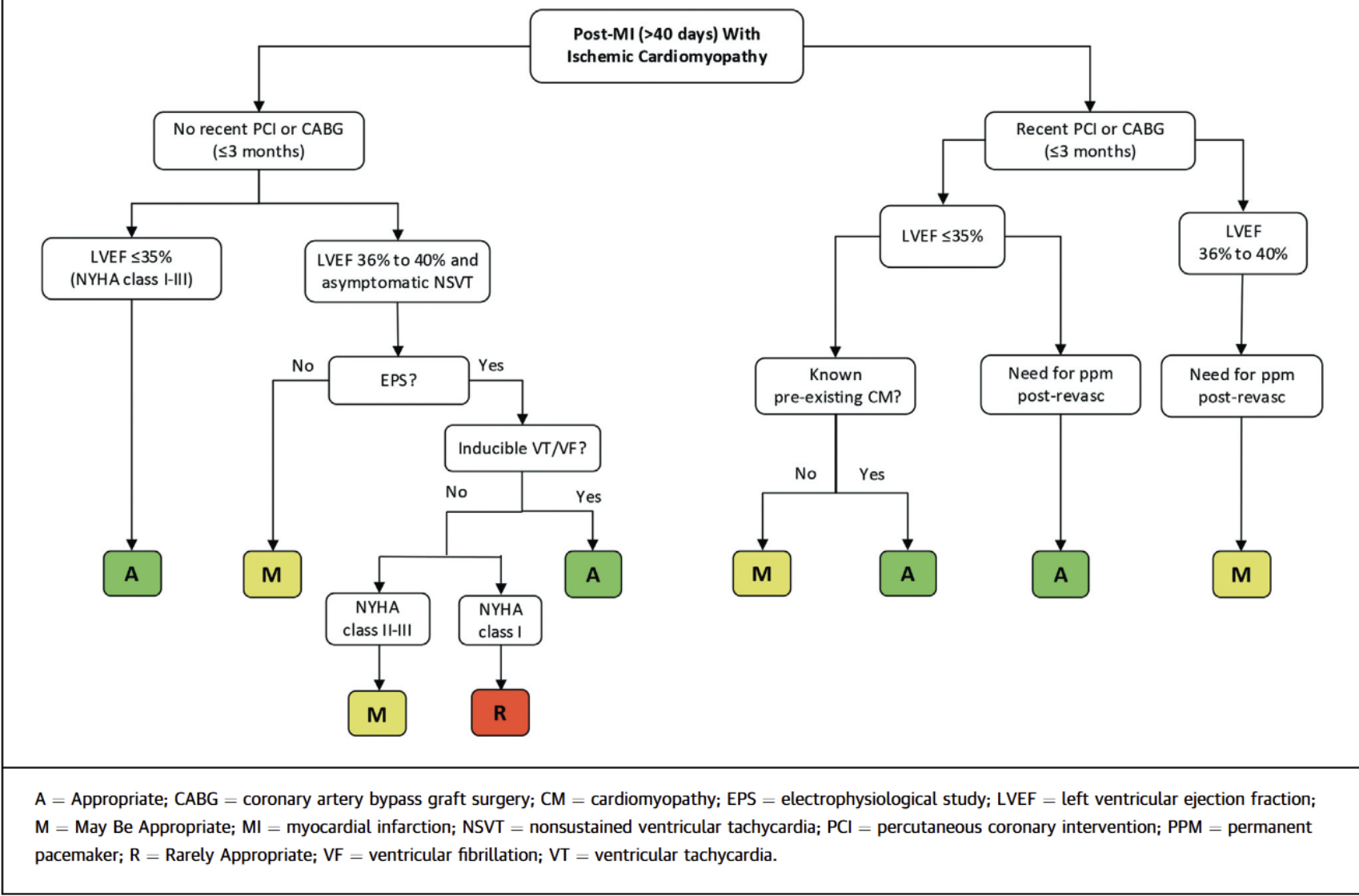
Caution: S-ICD is an investigational device limited
to investigational use only under US federal law. Not for sale.

Extravascular ICD



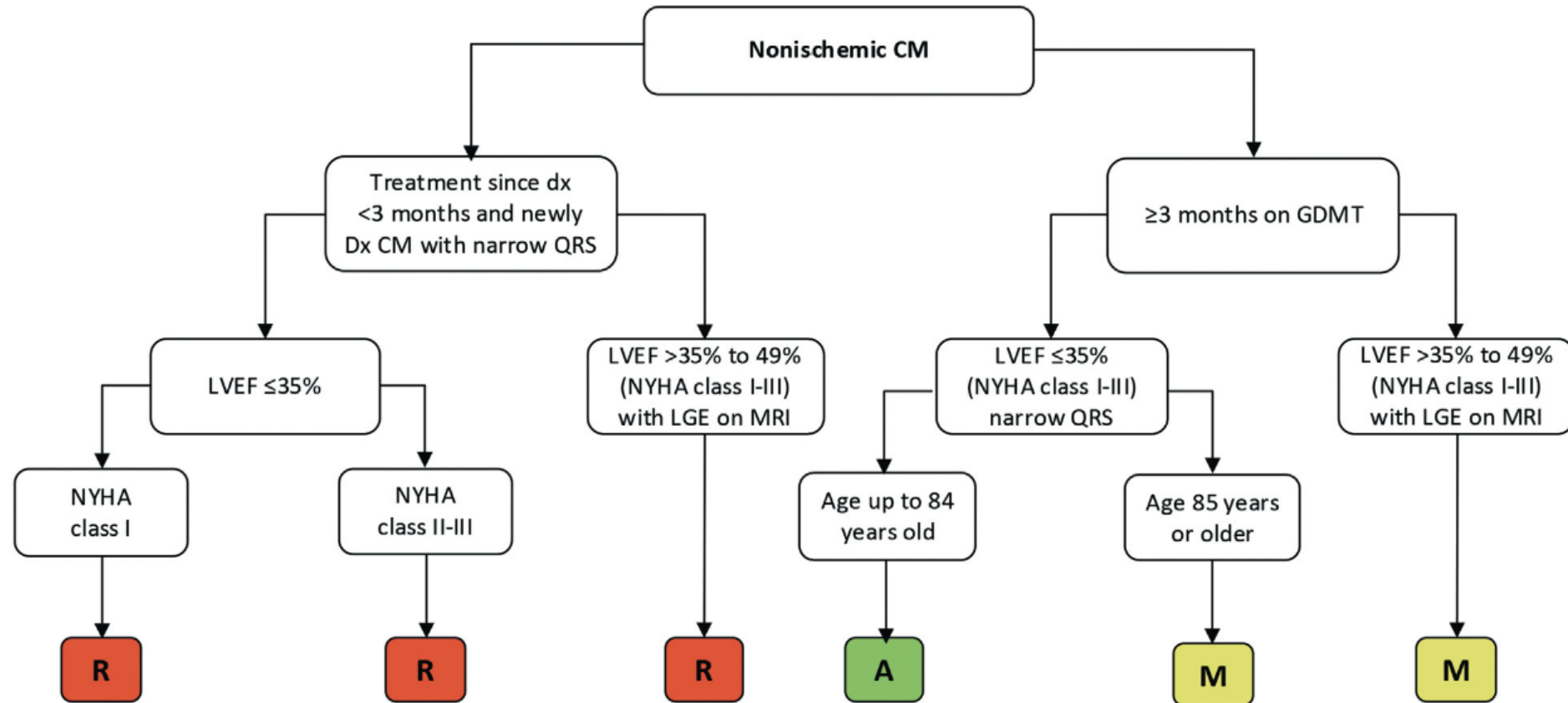
Primary prevention: Ischemic Heart Disease

FIGURE 10 Summary of Tables 2.1.3 and 2.1.5, Primary Prevention, CAD



Primary prevention: Nonischemic Cardiomyopathy

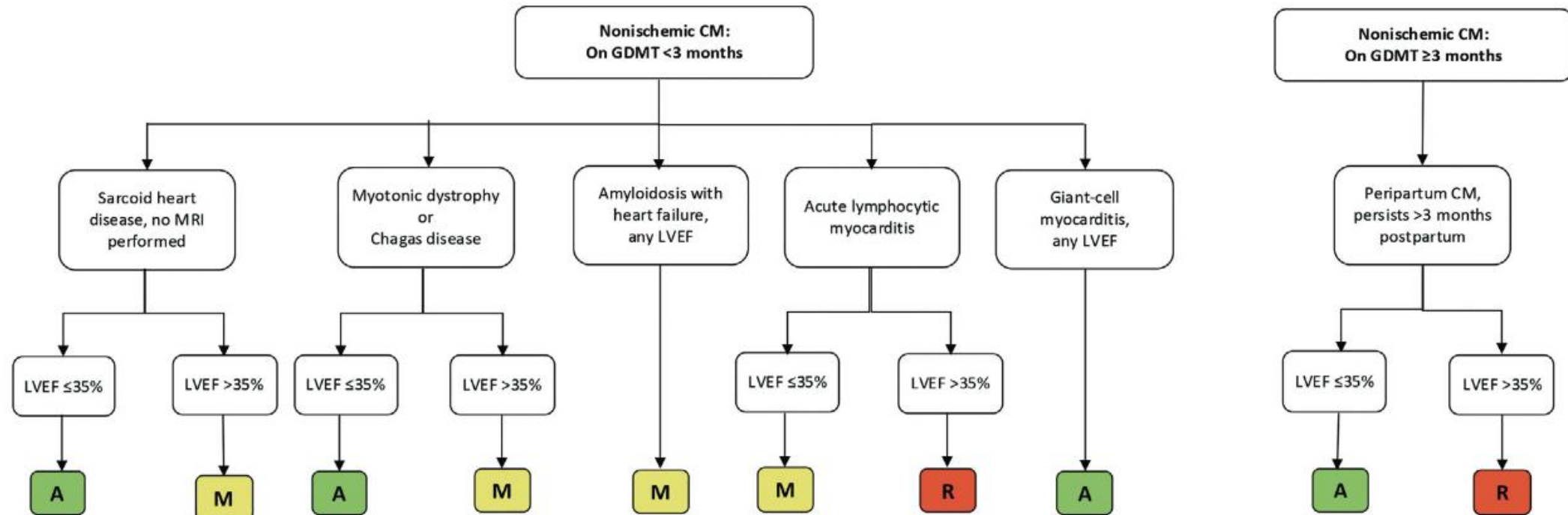
FIGURE 11 Summary of Table 2.2.1, Primary Prevention: Nonischemic Cardiomyopathy and Treatment Duration



A = Appropriate; CM = cardiomyopathy; Dx = diagnosed; GDMT = guideline-directed medical therapy; LGE = late gadolinium enhancement; LVEF = left ventricular ejection fraction; M = May Be Appropriate; MRI = magnetic resonance imaging; NYHA = New York Heart Association; R = Rarely Appropriate.

Primary prevention: Nonischemic Cardiomyopathy: who should get an ICD without 3 months of GDMT?

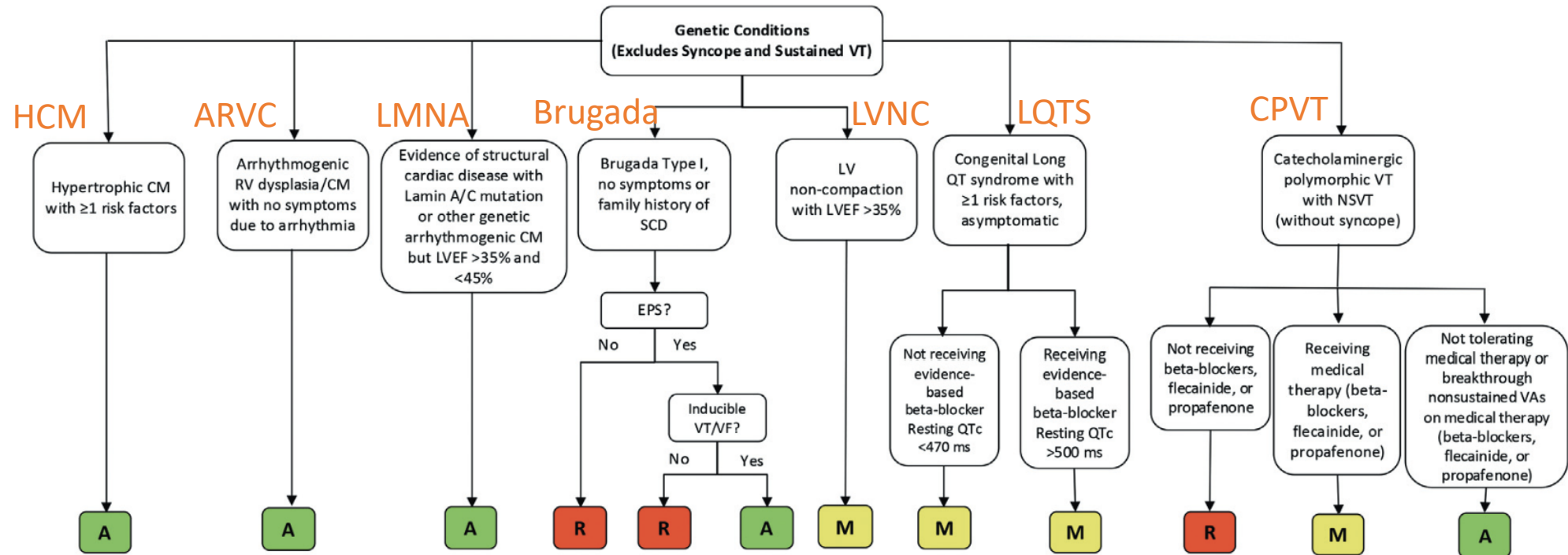
FIGURE 13 Summary of Table 2.2.3, Nonischemic CM, Specific Etiologies



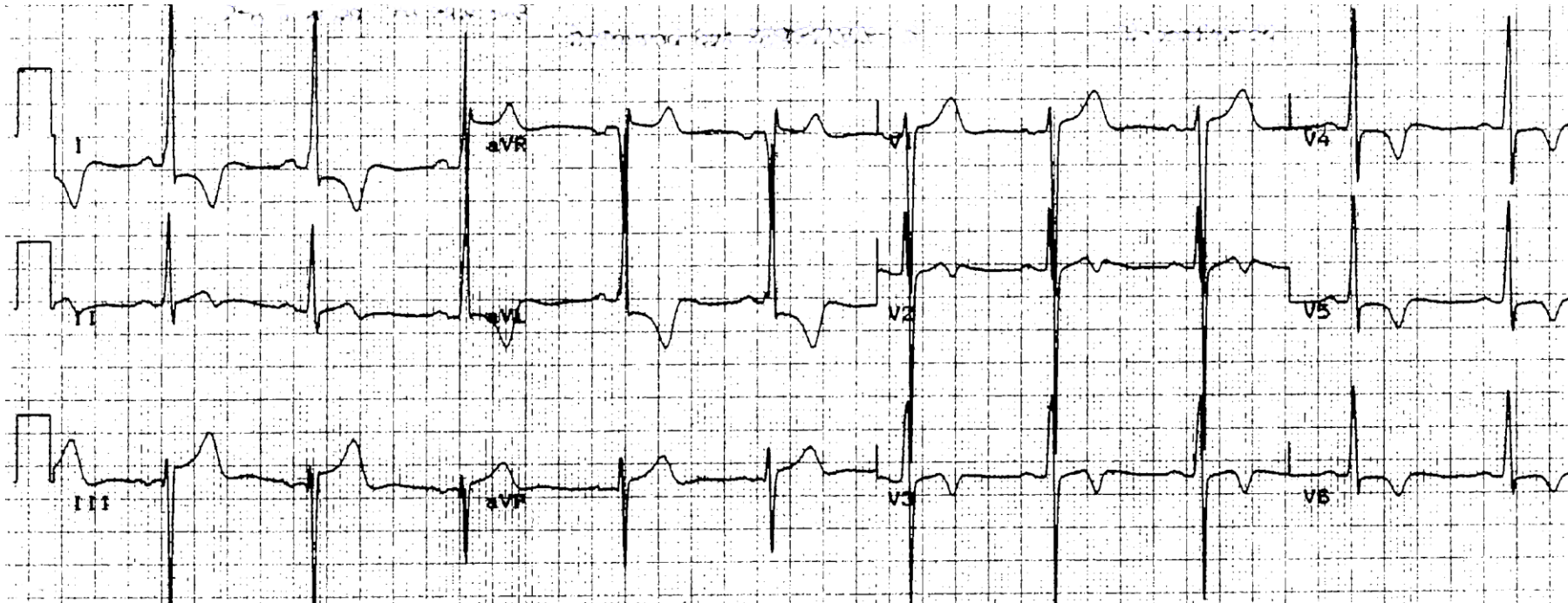
A = Appropriate; CM = cardiomyopathy; GDMT = guideline-directed medical therapy; LVEF = left ventricular ejection fraction; M = May Be Appropriate; MRI = magnetic resonance imaging; R = Rarely Appropriate.

Primary prevention: Genetic Conditions With and Without Structural Heart Disease

FIGURE 14 Summary of Table 2.3, Primary Prevention: Genetic Conditions With Structural Heart Disease



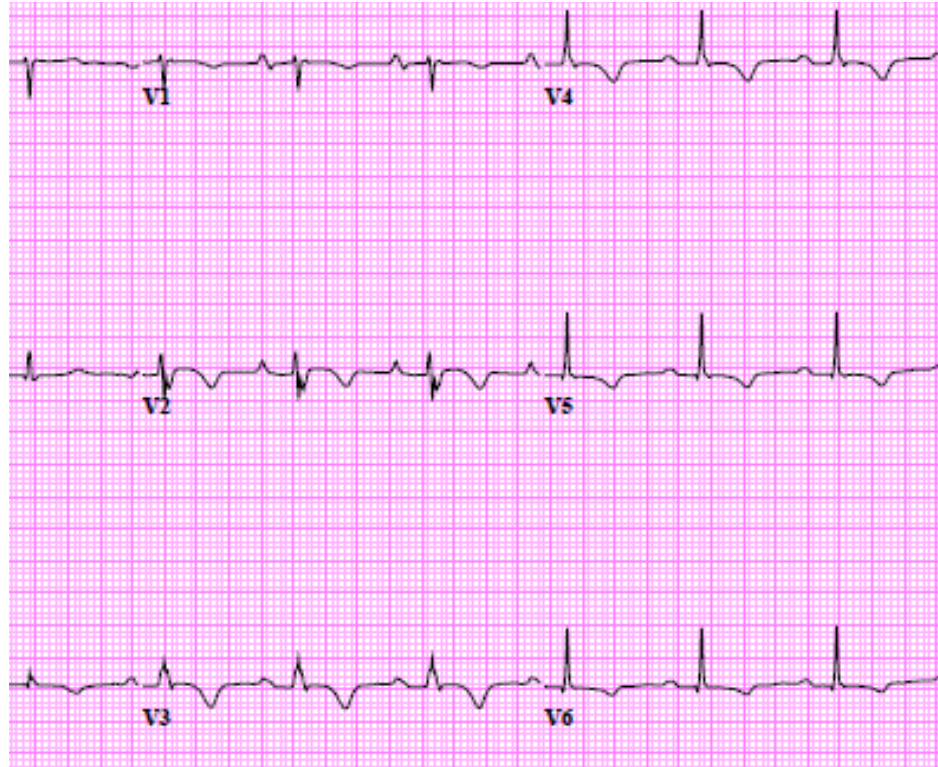
*Risk factors include maximum LV wall thickness ≥ 30 mm, SCD in ≥ 1 first-degree relative presumably caused by HCM, ≥ 1 episode of unexplained syncope within the preceding 6 months, spontaneous NSVT, and an abnormal blood pressure response with exercise. A = Appropriate; ACM = arrhythmogenic cardiomyopathy; CM = cardiomyopathy; EPS = electrophysiology study; HCM = hypertrophic cardiomyopathy; LV = left ventricle; LVEF = left ventricular ejection fraction; M = May Be Appropriate; NSVT = nonsustained ventricular tachycardia; R = Rarely Appropriate; RV = right ventricular; SCD = sudden cardiac death; VA = ventricular arrhythmia; VF = ventricular fibrillation; VT = ventricular tachycardia.



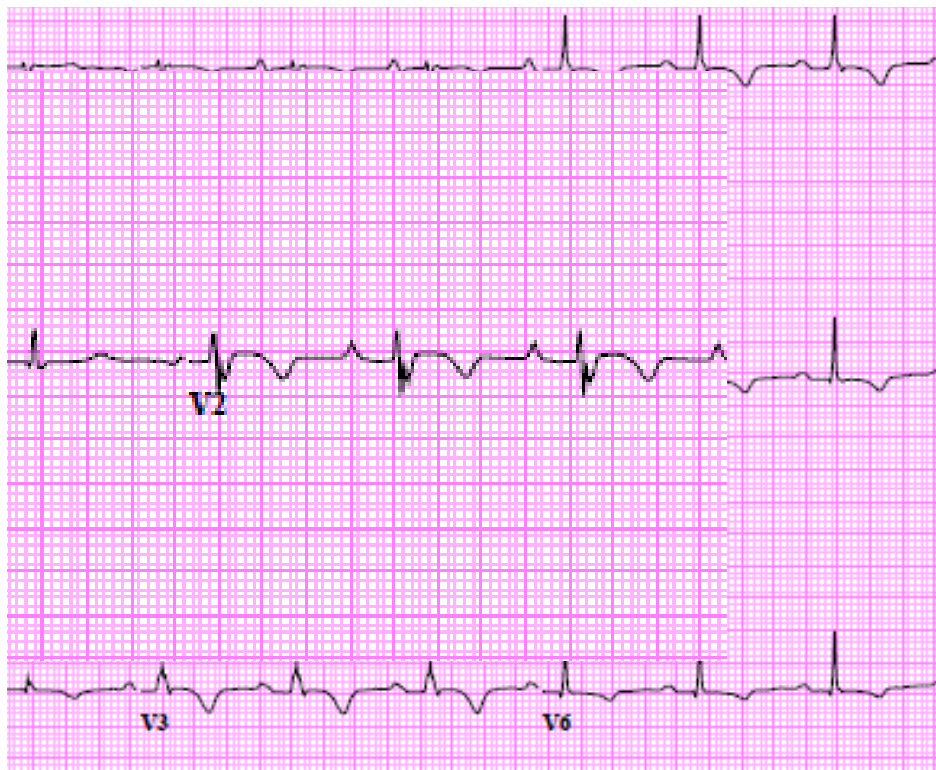
- 1. The ECG suggests which of the following:
 - A. Hypertrophic cardiomyopathy
 - B. Arrhythmogenic right ventricular dysplasia
 - C. Brugada syndrome
 - D. Congenital long QT syndrome
 - E. Familial Dilated Cardiomyopathy

Hypertrophic Cardiomyopathy

- Prevalence 1 in 500
- LVH or repolarization abnormalities in 85% of patients
- Palpitations due to atrial fibrillation
- Sudden death risk 1 – 3% per year



4. The ECG suggests which of the following:
- A. Hypertrophic cardiomyopathy
 - B. Arrhythmogenic right ventricular dysplasia
 - C. Brugada syndrome
 - D. Congenital long QT syndrome
 - E. Familial dilated cardiomyopathy

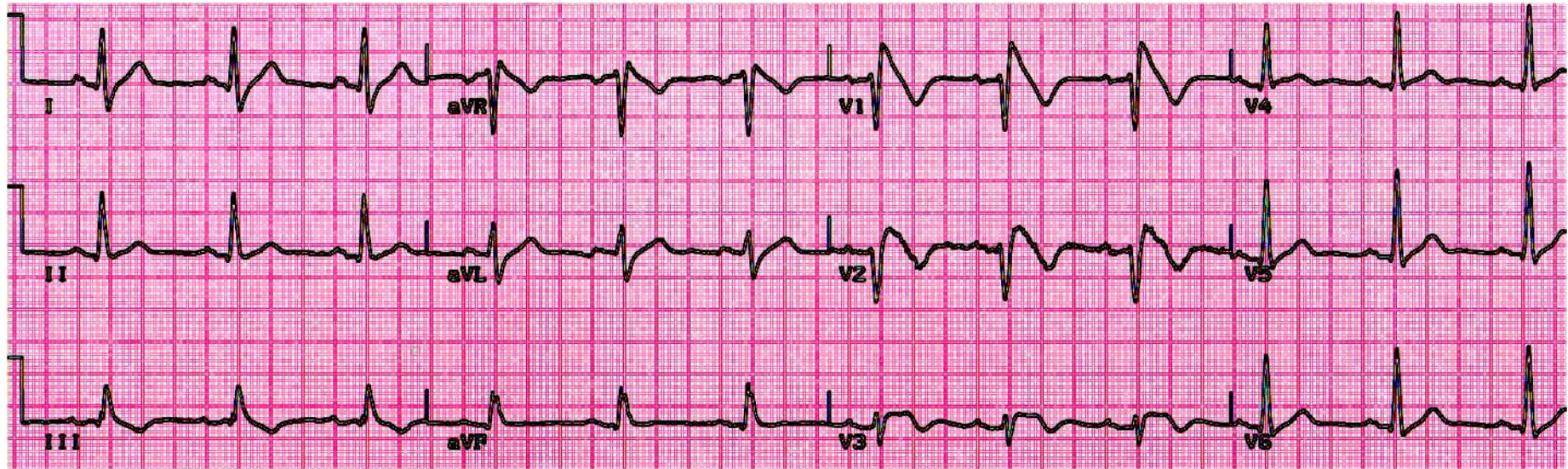


4. The ECG suggests which of the following:
- A. Hypertrophic cardiomyopathy
 - B. Arrhythmogenic right ventricular dysplasia
 - C. Brugada syndrome
 - D. Congenital long QT syndrome
 - E. Familial dilated cardiomyopathy

Arrhythmogenic right ventricular dysplasia (arrhythmogenic cardiomyopathy)

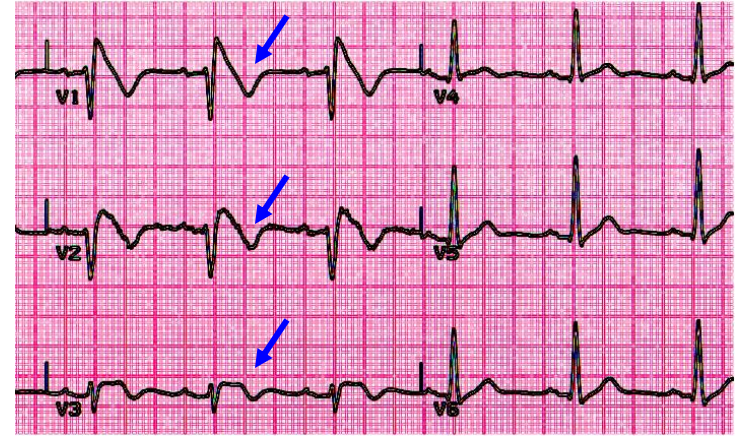
- Prevalence: 1/5000
- T-wave inversions in precordial leads in 85%
- fibrofatty infiltration of RV / LV
- VT with LBBB morphology – often exercise provoked
- Estimated mortality risk 3% per year
- Autosomal dominant and recessive forms
- at least 8 causative genes:
 - Cell adhesion proteins: plakophilin (27%), plakoglobin
 - ryanodine receptor, TGF-beta

Hulot et al. Natural history and risk stratification of ARVD. *Circulation*. 2004;110:1879.
Sen-Chowdhry et al. ARVC: clinical presentation, diagnosis, and mgmt. *Am J Med* 2004;117:685. Gerull, B. et al. Mutations in the desmosomal protein plakophilin-2 are common in ARVC. *Nat Genet* 36(11): 1162-4.



1. The ECG suggests which of the following:
 - A. Hypertrophic cardiomyopathy
 - B. Arrhythmogenic right ventricular dysplasia
 - C. Brugada syndrome
 - D. Congenital long QT syndrome
 - E. Familial dilated cardiomyopathy

Brugada syndrome



Sudden death due to PMVT – VF

- typically during sleep, fever
- Average age at first event: 41 yrs (range 2 - 77 yrs)

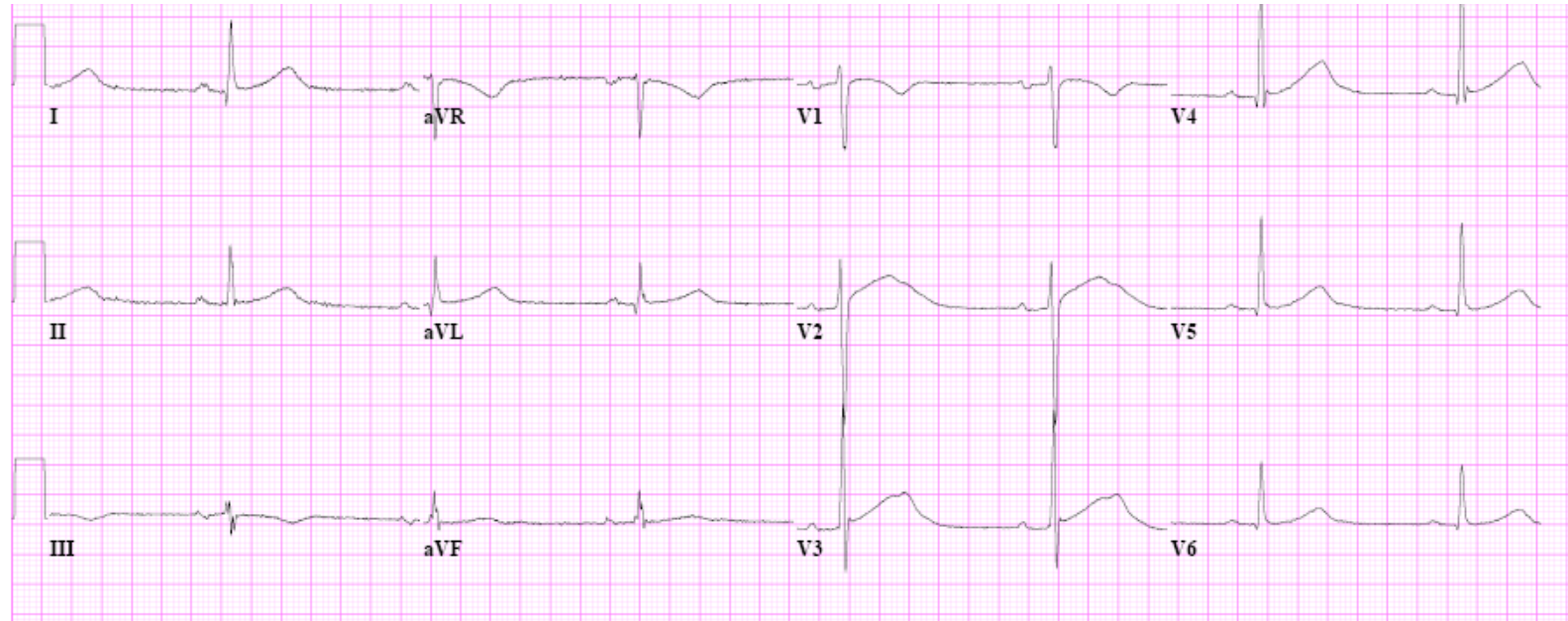
atrial arrhythmias and AV block also occur

Approx 20% have a sodium channel (SCN5A) mutation

Male and Asian predilection

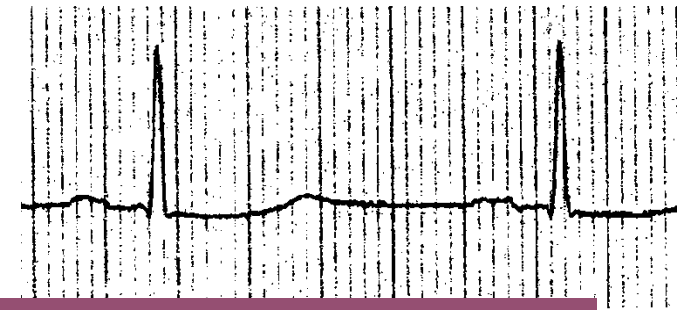
Risk of cardiac arrest approximately 10% per year - (may be substantially less if no arrhythmia symptoms at time of diagnosis)

ICD is protective

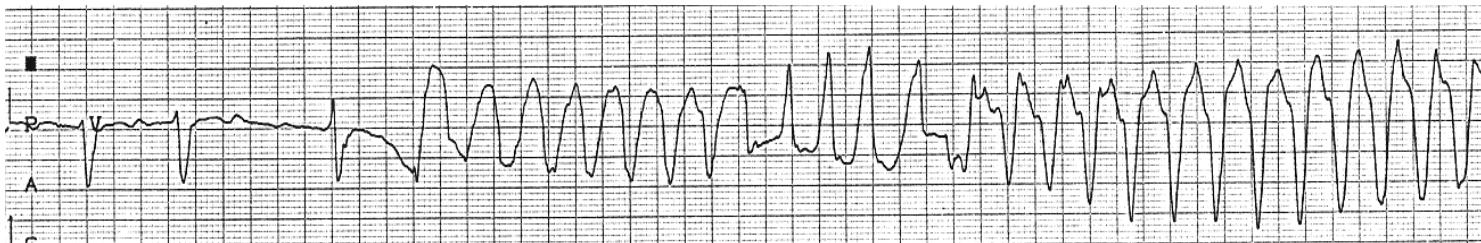


- 2. The ECG suggests which of the following:
 - A. Hypertrophic cardiomyopathy
 - B. Arrhythmogenic right ventricular dysplasia
 - C. Brugada syndrome
 - D. Congenital long QT syndrome
 - E. Familial dilated cardiomyopathy

Congenital Long QT syndrome



- mutations in genes coding for cardiac potassium or sodium channels
- autosomal dominant and recessive forms, variable penetrance.
- Presenting symptoms: syncope, sudden death
- ECG: QTc usually $\geq 0.46s$



Torsade de pointes

MOC REFLECTIVE STATEMENTS

- Bradycardia
 - Can be Physiologic or Pathologic
 - Monitoring during an episode is important for outpatient diagnosis
 - Many different ways to achieve pacing to minimize deleterious effects
- Sudden death
 - Epidemiology – always consider CAD, most common
 - Defibrillator implants for primary and secondary prevention in high risk structural heart disease and inherited disorders

References

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- Tracy CM et al. Heart Rhythm. 2012 Oct;9(10):1737-53
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- Moss AJ, et al. N Engl J Med. 2009;361:1329–1338
- Auricchio et al. European Heart Journal (2013) 34. 2281–2329
- Friedman P et al. N Engl J Med 2022;387:1292-302.
- Kusumoto F et al. J Am Coll Cardiol. 2019 Aug, 74 (7) e51–e156