AT THE FOREFRONT
UChicago Medicine

Cardiac Devices: A Patient-Focused Review

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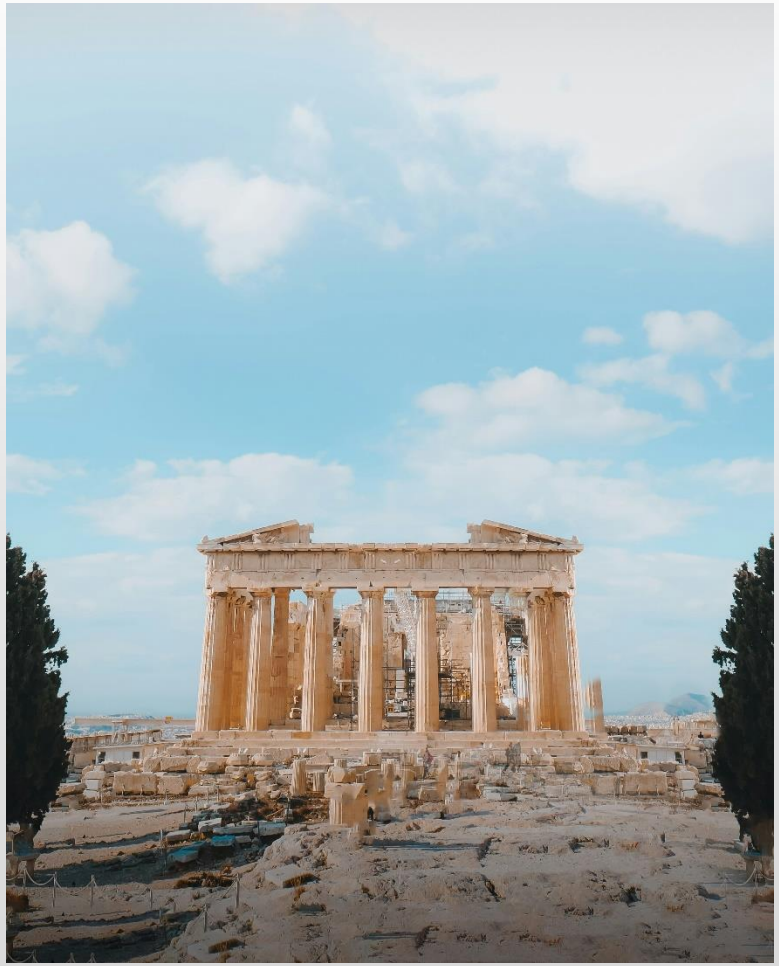
Disclosures

- None

Agenda

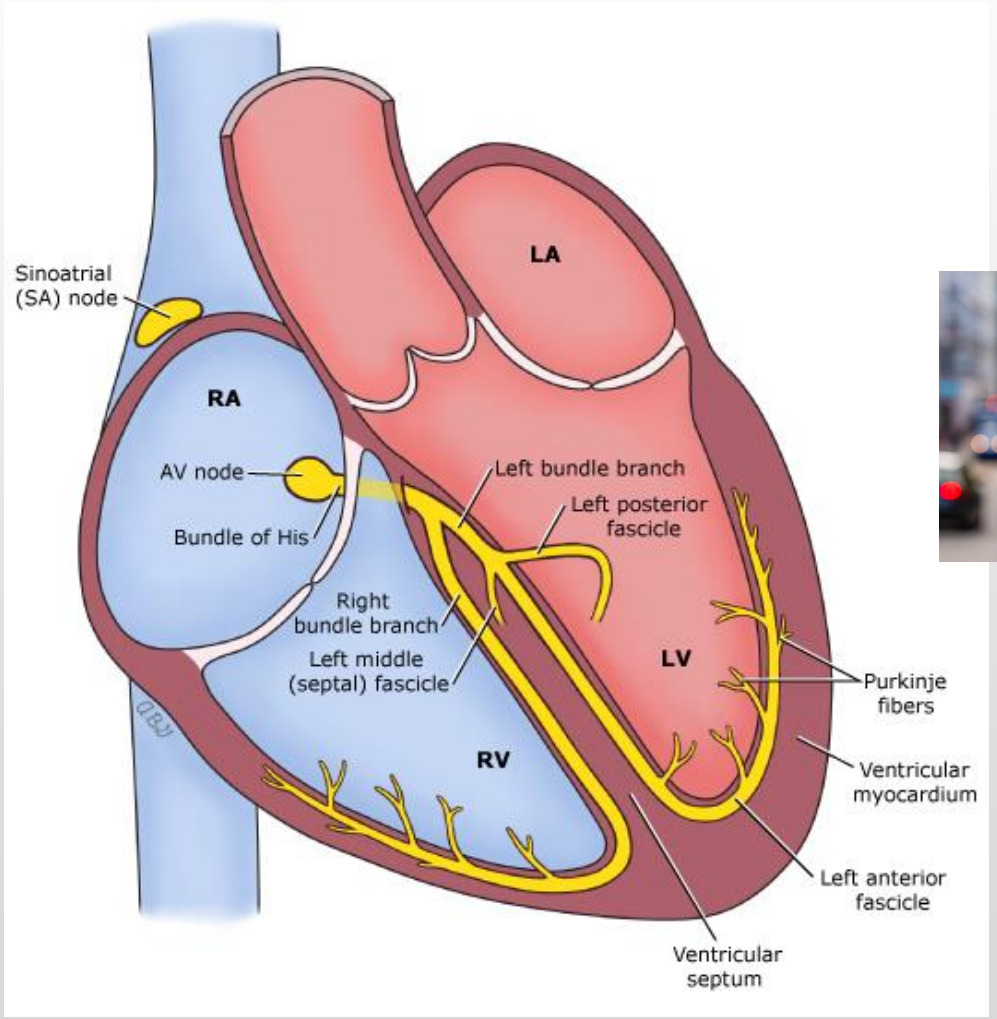
- Anatomy overview
- Pacemakers
- Device Infection
- Implantable Cardioverter Defibrillators (ICD)
- Programming Overview
- Cardiac Resynchronization Therapy (CRT)
- Subcutaneous Rhythm Monitor

Electrophysiology: It’s all Greek to me!



Heart = House

Cardiac Conduction



- Sinoatrial node (SA node)
  - Atrial Depolarization and Contraction
- Atrioventricular node (AV node)
  - Stop light between the atrium and ventricles
  - Rate Control
- His-Purkinje System (HPS)
  - Fast conduction
  - Bundle Branch
    - Right and Left
  - Ventricular depolarization and Contraction

UpToDate, Inc.

Arrhythmias

- Symptoms
  - Dizziness/ lightheadedness
  - Fatigue
  - Palpitations
  - SOB/ dyspnea
  - Chest pain
  - Syncope
- Diagnosis
  - ECG!
  - Telemetry
  - Holter/ event monitor
  - Device interrogation

Pacemakers vs Defibrillators

Pacemaker

- Increase heart rate through electrical impulses to cause myocardial contraction
- Treat slow heart rates
- Do not affect fast heart rates
- Monitor for ventricular tachycardia (VT) and ventricular fibrillation (VF)

Defibrillator

- Shocks the heart in the setting of VT/VF to restore sinus rhythm
- Transvenous defibrillators can ALSO pace the heart

Question 1

Does this patient meet indications for pacemaker?

- 74F presents with fatigue and inability to exercise as she could previously. When prompted she also states episodes of dizziness.
- Not on AV nodal blocking agents
- Exam notable for HR 50bpm
- Labs including electrolytes and TSH WNL
- Exercise stress shows max heart rate 70bpm with intermittent dizziness
- Home monitoring reveal sinus pause of 5.2 seconds while awake

Meets pacemaker indications!

Pacemaker Indications

- Sinus node dysfunction (with symptoms)
  - Sinus Bradycardia
    - Includes guideline driven medical therapy
  - Sinus Pauses
  - Tachy-brady Syndrome (IIa)
  - Sinoatrial Exit Block
  - Chronotropic Incompetence (Iia)
- High degree AV Block
  - Mobiz Type II
  - Complete Heart Block
- Heart Failure/ LBBB
  - Cardiac Resynchronization Therapy
- Overnight arrhythmias
  - Sleep study!

Recommendations for Permanent Pacing for Chronic Therapy/Management of Bradycardia Attributable to SND
Referenced studies that support recommendations are summarized in Online Data Supplements 24 and 25.

COR	LOE	Recommendations
I	C-LD	1. In patients with symptoms that are directly attributable to SND, permanent pacing is indicated to increase heart rate and improve symptoms.[S5.4.4-1,S5.4.4-2]
I	C-EO	2. In patients who develop symptomatic sinus bradycardia as a consequence of guideline-directed management and therapy for which there is no alternative treatment and continued treatment is clinically necessary, permanent pacing is recommended to increase heart rate and improve symptoms.
IIa	C-EO	3. For patients with tachy-brady syndrome and symptoms attributable to bradycardia, permanent pacing is reasonable to increase heart rate and reduce symptoms attributable to hypoperfusion.
IIa	C-EO	4. In patients with symptomatic chronotropic incompetence, permanent pacing with rate-responsive programming is reasonable to increase exertional heart rates and improve symptoms.
IIb	C-LD	5. In patients with symptoms that are likely attributable to SND, a trial of oral theophylline may be considered to increase heart rate, improve symptoms, and help determine the potential effects of permanent pacing.[S5.4.4-3,S5.4.4-4]

Pacemaker Contraindications

Active infection

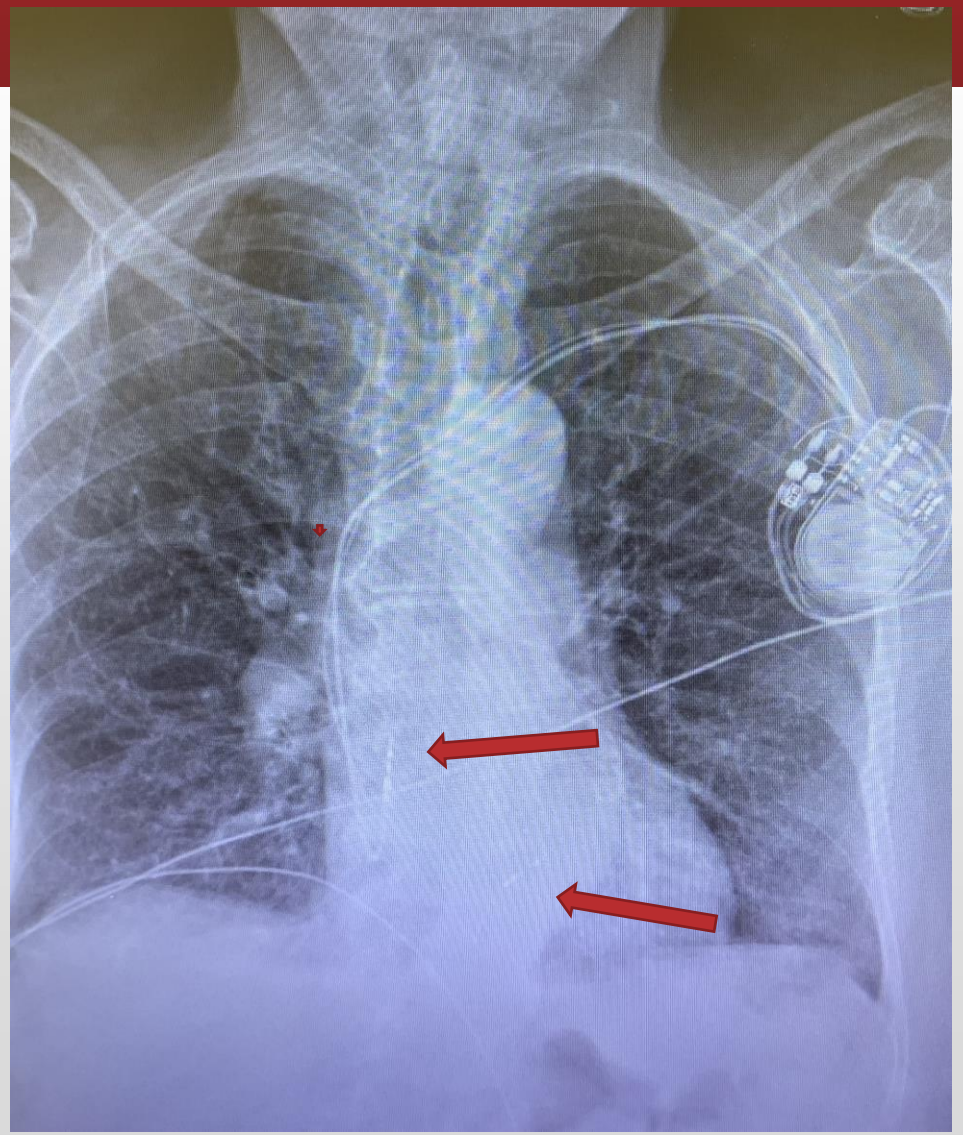
- Temporary pacemaker as needed

Relative contraindications

- Choose side based on lines or fistulas

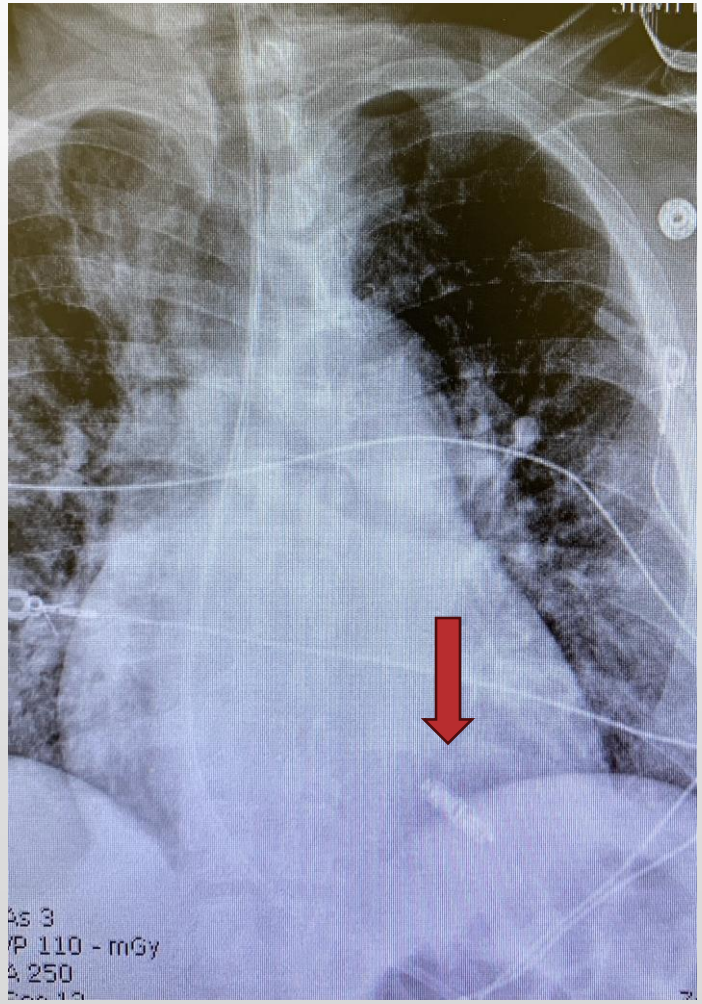
Pacemaker: Parts to a device

- Generator
  - “Can”
  - Programming
  - Battery lasts 8-12 years
  - Placed on non-dominant side
- Lead
  - “Wire”
  - Screws into the myocardium



Leadless Pacemaker

- Indication
  - Lower pacing burden
  - High infection risk
- Advantages
  - Low infection risk/ No pocket
  - No arm restrictions
- Disadvantages
  - Large delivery sheath
  - 6 hour bedrest
  - RV pacing only



Pacemakers	
SC-PM single chamber pacemaker	• 1 pacemaker lead/device in RA or RV
DC-PM dual chamber pacemaker	• 1 pacemaker lead in RA • 1 pacemaker lead in RV
CRT-P Cardiac resynchronization therapy pacemaker or biventricular pacemaker	• 1 pacemaker lead in RA • 1 pacemaker lead in RV • 1 pacemaker lead in coronary sinus (LV)

Question 2

1. Refer to plastic surgery

2. Electrophysiology urgent consult

3. Physical therapy wound consult

Device infection = EP emergency

CALL ELECTROPHYSIOLOGY!

Device Infection

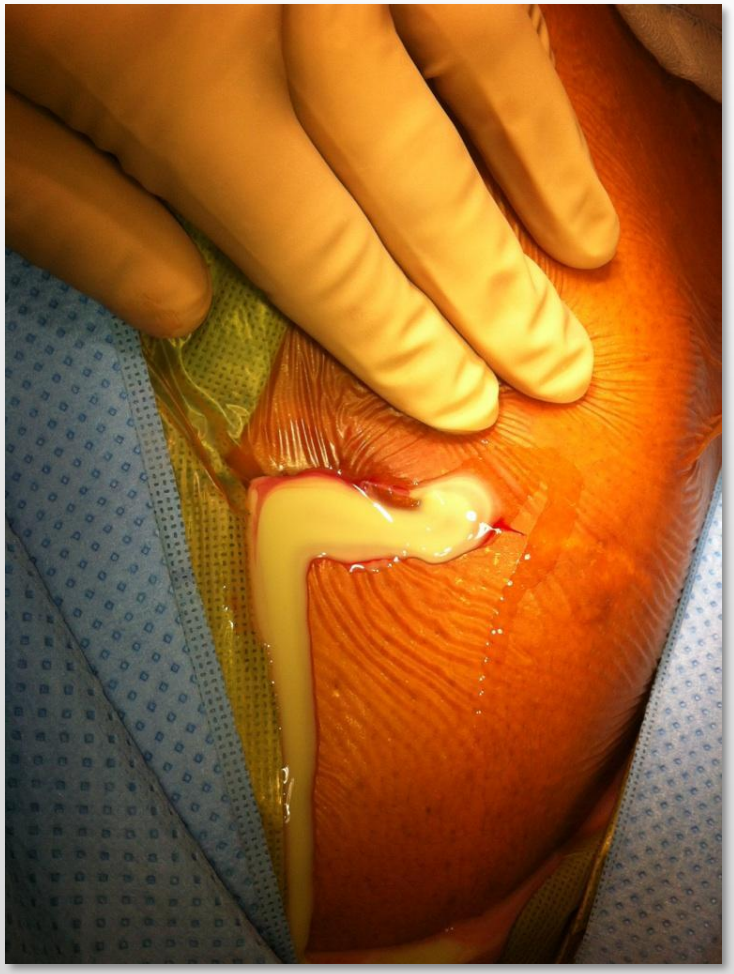
- Examples
  - Pocket infection
  - Endocarditis
  - Bacteremia
- Extraction Center for complete removal of device
- Higher risk with older implants
  *Risk of SVC tear
- Laser techniques
- CT surgery backup

CALL ELECTROPHYSIOLOGY!

Photos courtesy of Dr. Andrew Beaser

Device infection

CALL ELECTROPHYSIOLOGY!



Photos courtesy of Dr. Andrew Beaser

Question 3

Does this patient meet defibrillator indication?

45M presents with STEMI and receives PCI. EF was 25% and started on GDMT

Continues on GDMT for 3 months with persistent EF of 30%

Meets defibrillator indications!

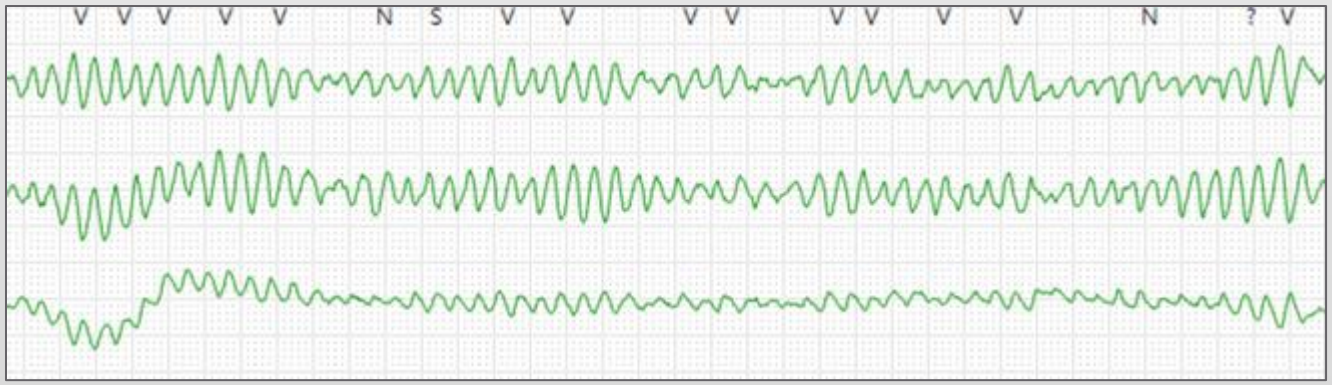
Implantable Cardioverter Defibrillator (ICD) Indications

Primary prevention ICD

- Those at risk of SCD
- EF <35% after 3 months of GDMT
- 40 days after MI LVEF <30%
- Congenital long QT
- Hypertrophic cardiomyopathy with high risk features
- Sarcoidosis
- High risk channelopathies

Secondary prevention ICD

- Individuals who had prior VT/VF without reversible causes
- VT/VF NOT within 48 hours of MI

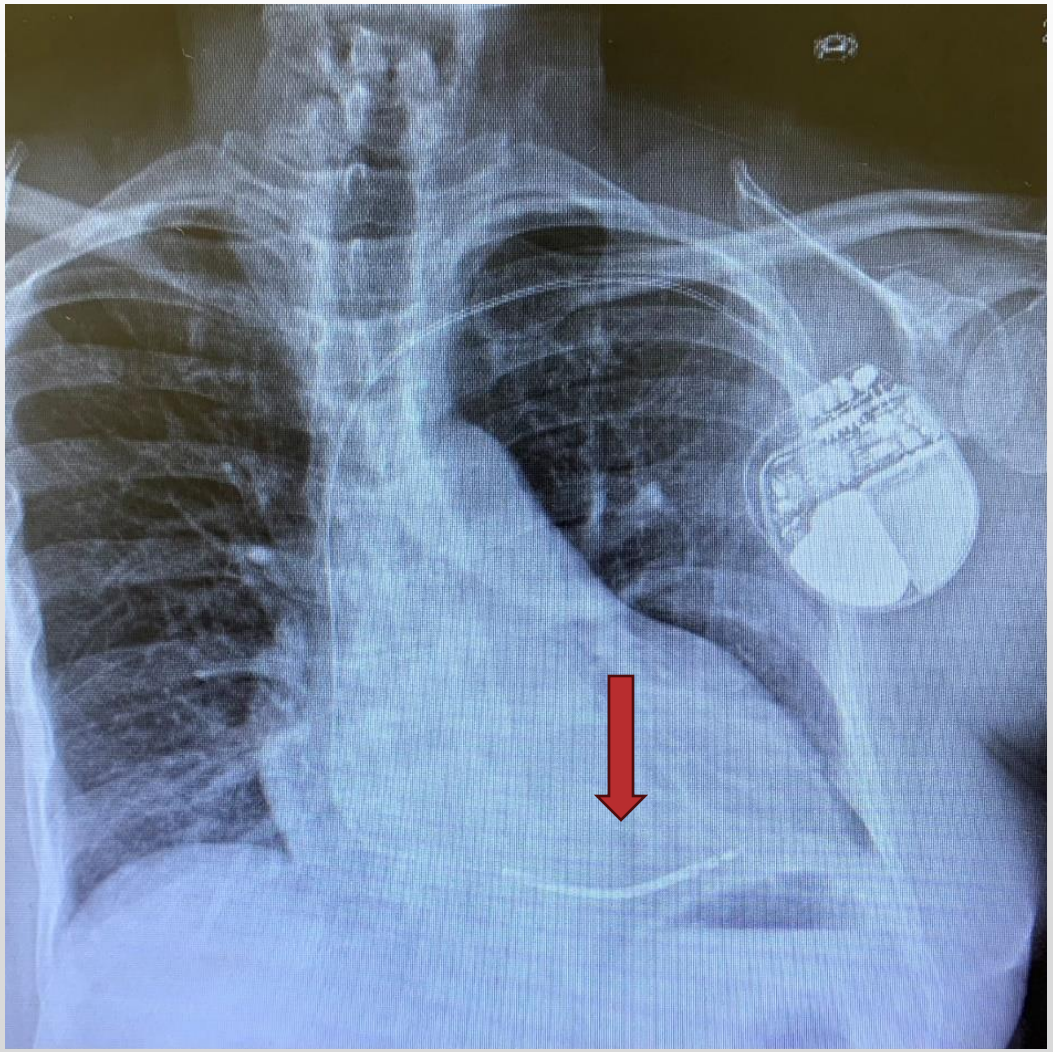


ICD contraindications

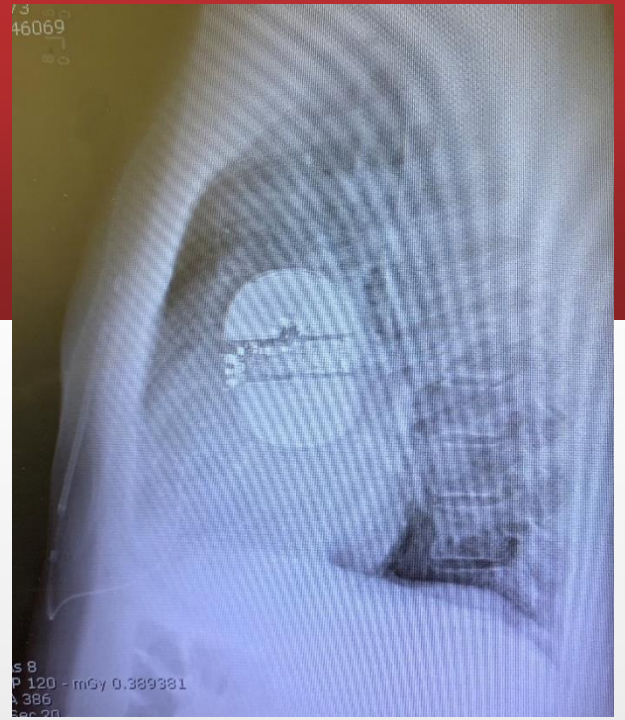
- Active infection
  - Wearable defibrillator
- Less than 1 year life expectancy
- Incessant VT/VF
- Severe psychiatric illness
- Syncope without inducible VT/VF or structural heart disease

Transvenous Defibrillator

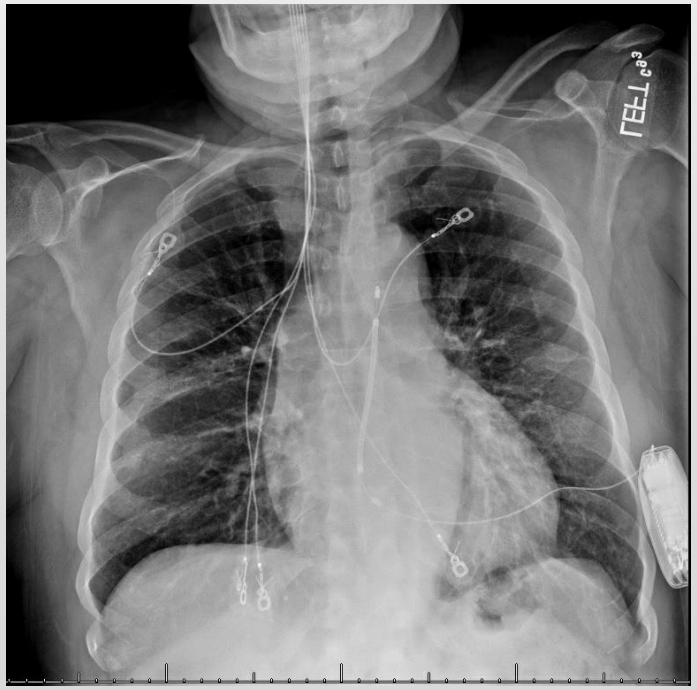
- Generator
  - “Can”
  - Programming
  - Battery lasts 7-10 years
  - Placed on left side
- Defibrillator lead
  - Screws into the right ventricle
  - Can pace the heart



Subcutaneous Defibrillator



- Indications
  - Young/ active
  - IVDU
  - Dialysis patient
- Advantages
  - Not in the vasculature; minimize infection risk
- Disadvantages
  - Only pacing capability is post-shock
  - Requires passing screening tool



Implantable Cardioverter Defibrillator – ICD	
SC-ICD single chamber defibrillator	• 1 defibrillator lead in RV
DC-ICD dual chamber defibrillator	• 1 pacemaker lead in RA • 1 defibrillator lead in RV
CRT-D cardiac resynchronization therapy defibrillator or biventricular defibrillator	• 1 pacemaker lead in RA • 1 defibrillator lead in RV • 1 pacemaker lead in coronary sinus (LV)
S-ICD subcutaneous defibrillator	

Device Programming- Pacing

Types: AAI, DDD, VVI, DDDR, etc

First Letter

- Location of pacing (atrium, ventricle, dual)

Second Letter

- Location of sensing (atrium, ventricle, dual)

Third Letter

- Response to sensing
  - I: Inhibition
  - T: Triggered
  - D: Dual (Triggered and Inhibition)
  - O: None

R

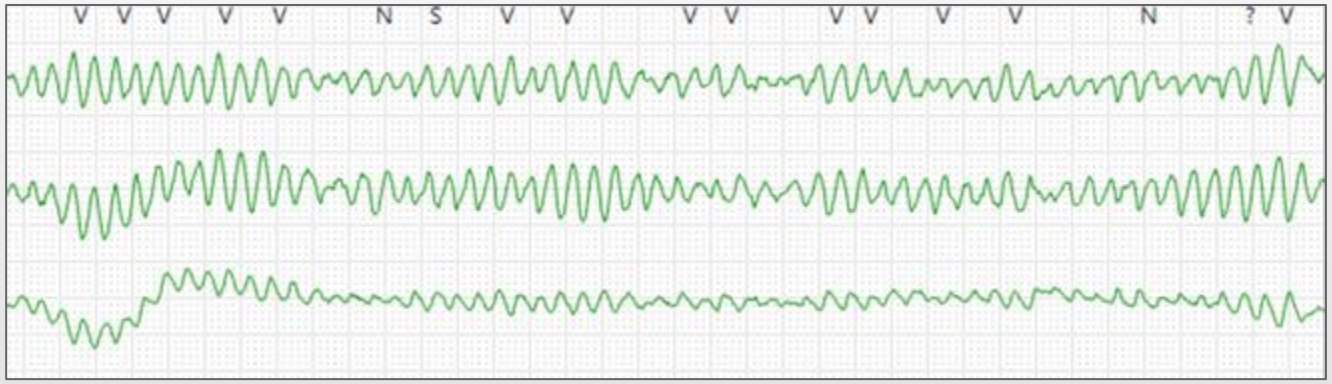
- Rate responsiveness

Device Programming- Pacing

- VVI
  - V: Pacing in ventricle
  - V: Sensing in ventricle
  - I: Inhibition (Inhibit pacing in response to sensing)
  - Commonly seen in primary prevention ICDs
- DDD
  - D: Pacing in atrium and ventricle
  - D: Sensing in atrium and ventricle
  - D: Dual (triggered and inhibition)
  - Commonly seen in DC-PM

Device Programming- Shocking

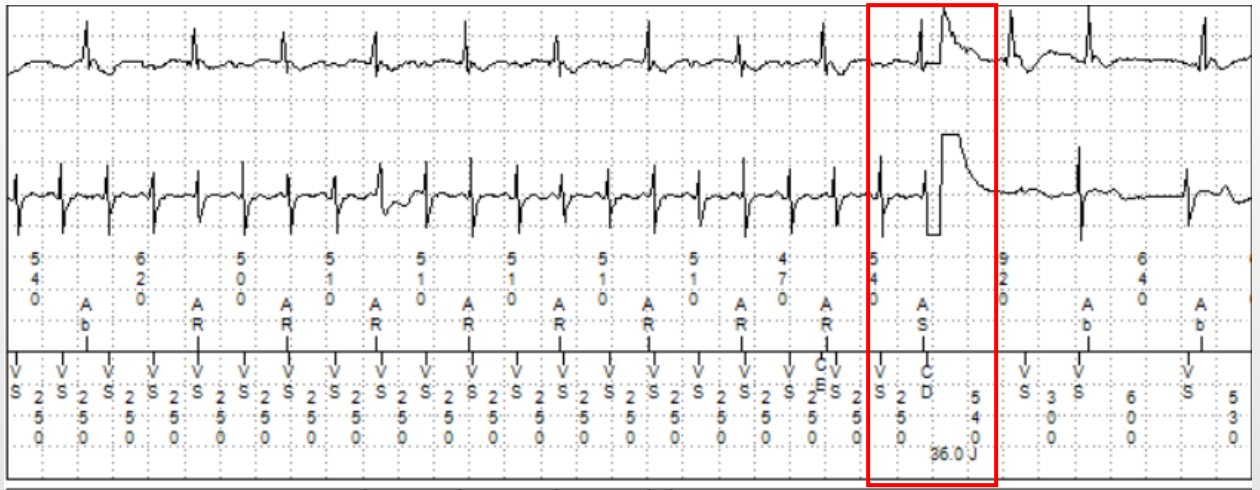
- Different device companies have different algorithms/ programmability
- 1-2 VT zones and 1 VF zone
  - Can add monitor zone
- Zone is set to a rate
  - Device also looks at morphology
- Antitachycardia Pacing (ATP)
  - Pacing stimuli delivered by the device to convert VT/VF to sinus rhythm without delivering a shock



Successful ICD shock

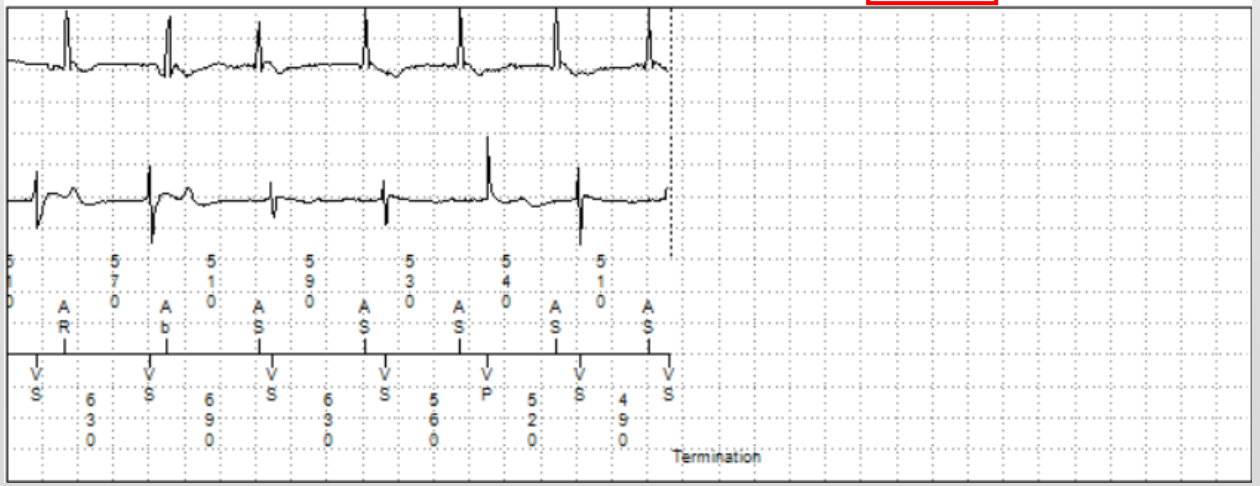
Atrial Lead

Ventricular Lead



Atrial Lead

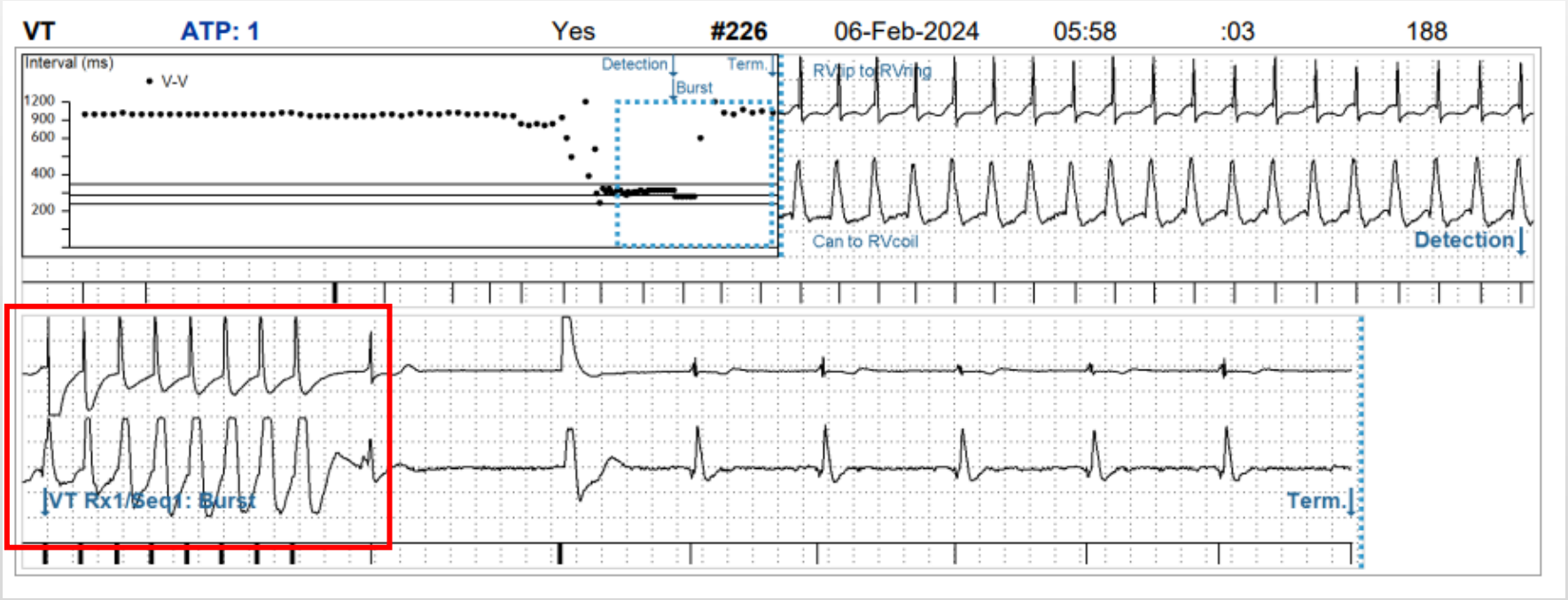
Ventricular Lead



Antitachycardia Pacing (ATP)

- Pacing stimuli delivered by the device to convert VT/VF to sinus rhythm without delivering a shock
- Intension to interrupt the circuit

Single Chamber Defibrillator



Shock Support Groups

- ICD shocks can be psychologically debilitating and lead to post traumatic stress disorder
- Encourage patients and loved ones to discuss trauma with others sharing similar experiences
- Online support groups
- Refer to psychiatry

Hang in there

Question 4

Question

64M with PMH of complete heart block s/p DC-PM who was found to have EF 20% on recent echocardiogram. Workup without underlying cardiac condition. Recent device interrogation found well functioning device with RV pacing 100%. Patient started on GDMT. What are the next steps?

1. Refer to rheumatology
2. Refer to surgery for LVAD
3. Refer to palliative care
4. Discuss possible device upgrade with electrophysiology

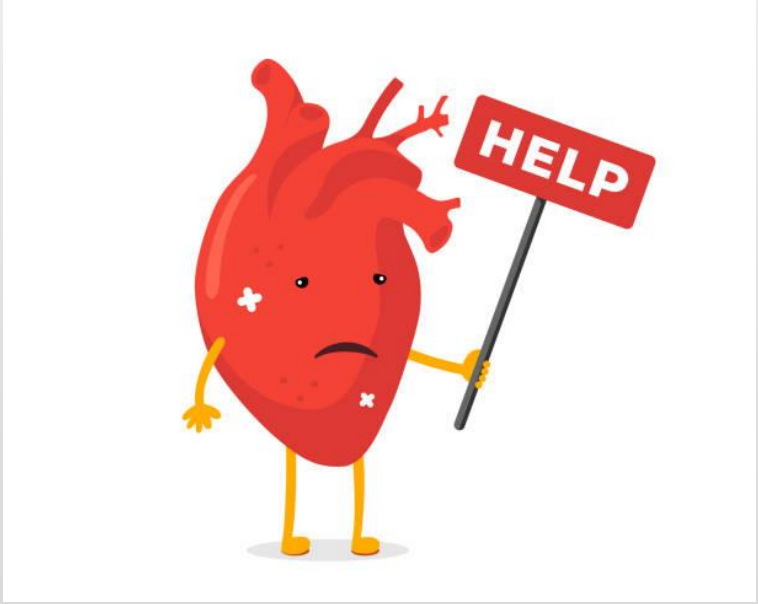
Answer

64M with PMH of complete heart block s/p DC-PM and HTN who was found to have EF 20% on recent echocardiogram. Recent interrogation found well functioning device with RV pacing 100%. What are the next steps?

1. Refer to rheumatology for sarcoidosis work up
2. Refer to surgery for LVAD
3. Refer to palliative care
4. Discuss possible device upgrade with electrophysiology

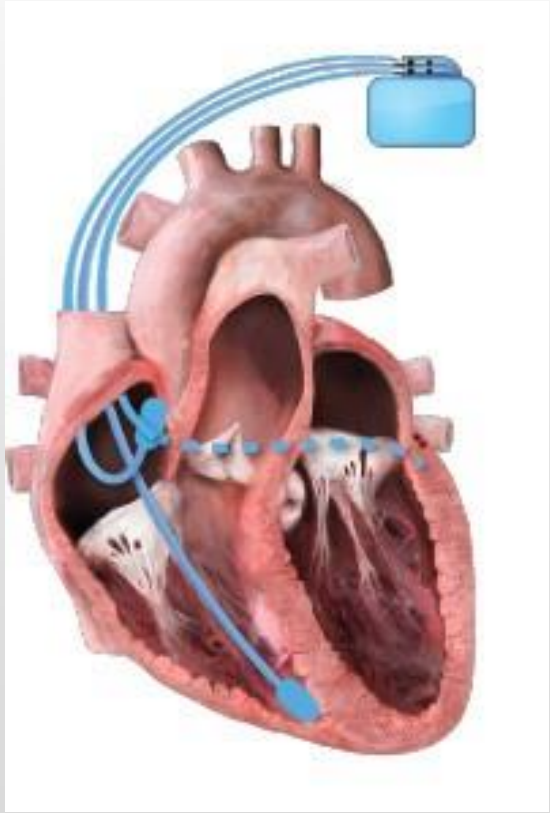
Pacemaker Induced Cardiomyopathy

- Decline in left ventricle ejection fraction in the setting of chronic, high burden right ventricle pacing
- LVEF <40% or 50% with 5-10% drop in EF
- Occurs in 10-20% of patients
- Attempt to reduce pacing
  - Change rate
  - Change AV delays
  - If unable, consider CRT upgrade



Cardiac Resynchronization Therapy (CRT)

- Intention to improve cardiac function by creating synchrony
- Also called biventricular pacing (BiV)
- Indications
  - Symptomatic heart failure
  - LBBB
  - QRS >150ms if non-LBBB
  - Pacing >40%
- Goal is to pace the heart 100% of the time
- Different poles allow for programming changes
- 3 lead system
  - RA, RV, LV (CS)



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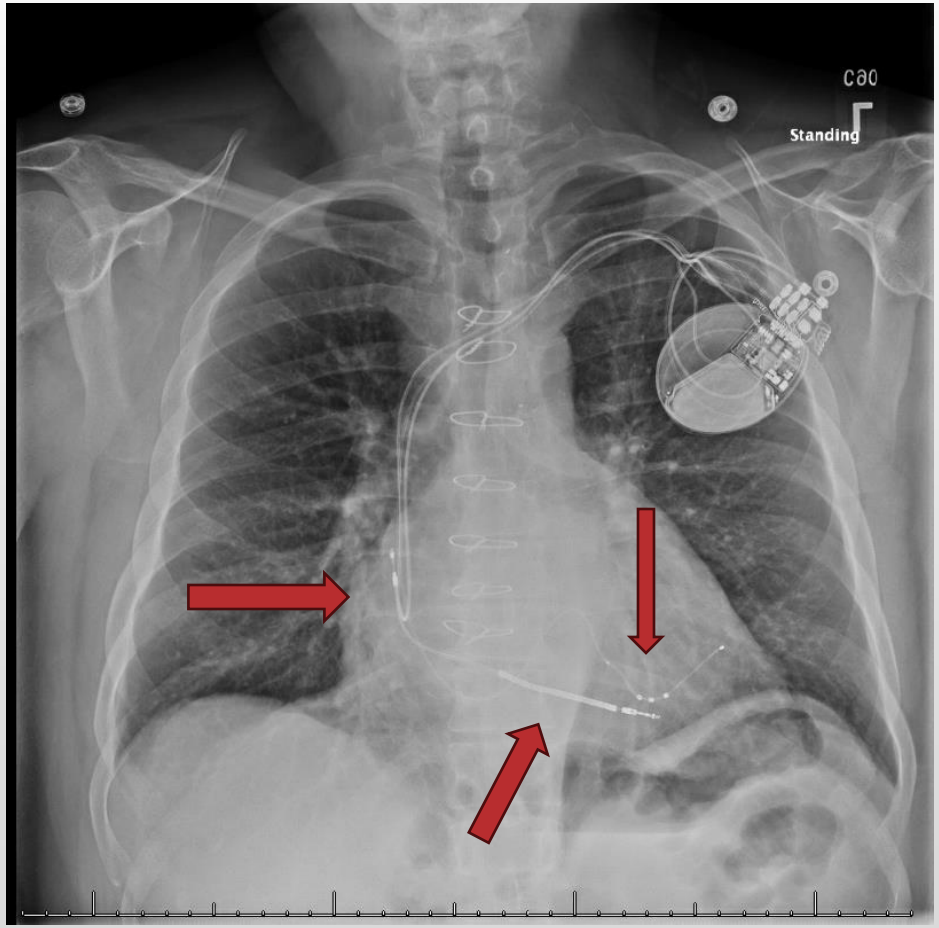
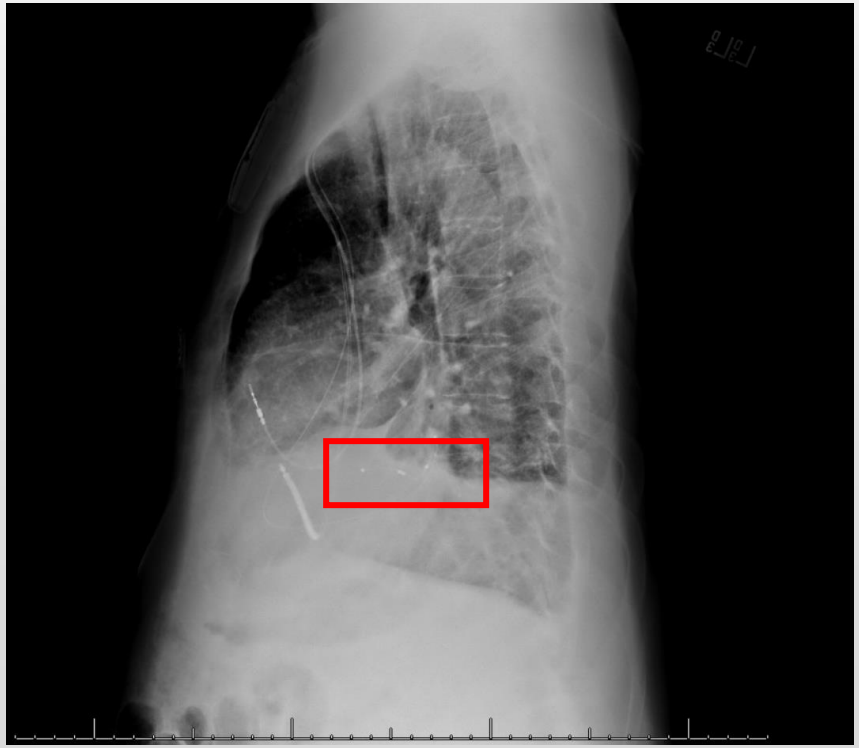
Cardiac Resynchronization Therapy (CRT)

- Reduce heart failure symptoms
- Reduce hospitalizations
- Improve ejection fraction
- Increased survival



Diaphragmatic Stimulation

- Complication of LV lead placement stimulating phrenic nerve causing diaphragmatic stimulation
- Can feel diaphragm contracting
- Testing for during placement of the lead
- Not harmful, but uncomfortable to patients
- Can be position based
- Solutions
  - Change pacing vector
  - Lower output

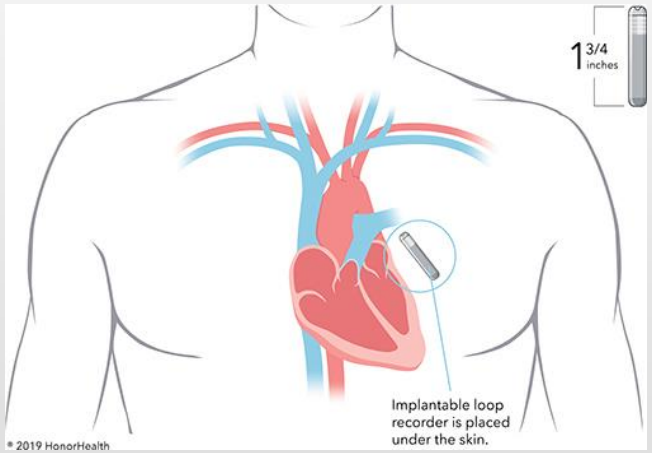


Subcutaneous Rhythm Monitor

Subcutaneous Rhythm Monitor/ Loop Recorder

- Implanted event recorder
- Long term monitoring
  - 3-6 years
- Auto and symptom triggers
- Home monitoring system

- Indications
  - Diagnosis
  - Cryptogenic stroke
  - Arrhythmia management



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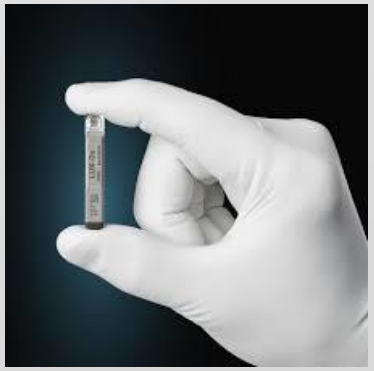
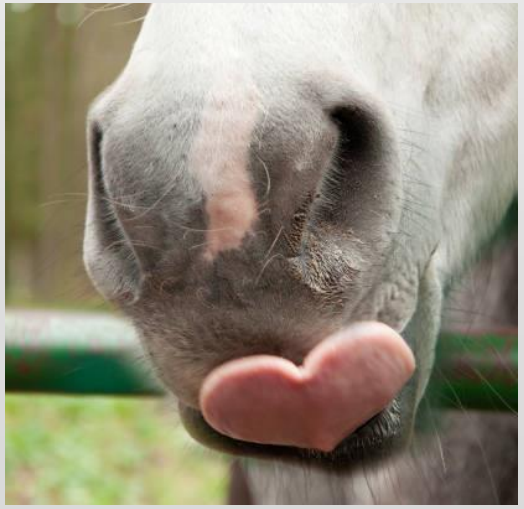


Summary

- Pacemakers
  - Increase heart rate for sinus node dysfunction, heart block, or HFrEF/ LBBB
- Defibrillators
  - Shock the heart to restore sinus rhythm in the setting of VT/VF
  - Given as primary or secondary prevention
  - Transvenous defibrillators also pace the heart
- Infection is a lifelong risk of devices
- CRT devices to improve HF outcomes
- Subcutaneous rhythm monitors provide long term arrhythmia monitor



References

- Al-Khatib, S. (2018). 2017 AHA/ACC/HRS Guideline for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death: Executive Summary. Circulation, 138, 210–271.
- Babcock O'Connell, C & Cogan-Drew, T. 'A comprehensive review for the certification and recertification examinations for PAs 7th Edition'. Wolters Kluwer. 2022.
- Chung MK, Patton KK, Lau CP, Dal Forno ARJ, Al-Khatib SM, Arora V, Birgersdotter-Green UM, Cha YM, Chung EH, Cronin EM, Curtis AB, Cygankiewicz I, Dandamudi G, Dubin AM, Ensch DP, Glotzer TV, Gold MR, Goldberger ZD, Gopinathannair R, Gorodeski EZ, Gutierrez A, Guzman JC, Huang W, Imrey PB, Indik JH, Karim S, Karpawich PP, Khaykin Y, Kiehl EL, Kron J, Kutyifa V, Link MS, Marine JE, Mullens W, Park SJ, Parkash R, Patete MF, Pathak RK, Perona CA, Rickard J, Schoenfeld MH, Seow SC, Shen WK, Shoda M, Singh JP, Slotwiner DJ, Sridhar ARM, Srivatsa UN, Stecker EC, Tanawuttiwat T, Tang WHW, Tapias CA, Tracy CM, Upadhyay GA, Varma N, Vernooy K, Vijayaraman P, Worsnick SA, Zareba W, Zeitler EP. 2023 HRS/APHRS/LAHRS guideline on cardiac physiologic pacing for the avoidance and mitigation of heart failure. Heart Rhythm. 2023 Sep;20(9):e17-e91. doi: 10.1016/j.hrthm.2023.03.1538. Epub 2023 May 20. PMID: 37283271.
- Dakkak W, Doukky R. Sick Sinus Syndrome. [Updated 2021 Jul 21]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-.
- De Maria E, Giacopelli D, Borghi A, Modonesi L, Cappelli S. Antitachycardia pacing programming in implantable cardioverter defibrillator: A systematic review. World J Cardiol. 2017 May 26;9(5):429-436. doi: 10.4330/wjc.v9.i5.429. PMID: 28603590; PMCID: PMC5442411.
- Glikson M, Nielsen JC, Kronborg MB, Michowitz Y, Auricchio A, Barbash IM, Barrabés JA, Boriani G, Braunschweig F, Brignole M, Burri H, Coats AJS, Deharo JC, Delgado V, Diller GP, Israel CW, Keren A, Knops RE, Kotecha D, Leclercq C, Merkely B, Starck C, Thylén I, Tolosana JM; ESC Scientific Document Group. 2021 ESC Guidelines on cardiac pacing and cardiac resynchronization therapy. Eur Heart J. 2021 Sep 14;42(35):3427-3520. doi: 10.1093/eurheartj/ehab364. Erratum in: Eur Heart J. 2022 May 1;43(17):1651. PMID: 34455430.
- Ibrahim, N. E., Sauer, A., Singh, J. P., & Upadhyay, G. (2023). Integrating Care Solutions For the Patient Receiving Cardiac Resynchronization Therapy. Journal of the American College of Cardiology. https://doi.org/10.1016/j.jacc.2023.02.003
- Khurshid S., Epstein A.E., Verdino R.J. et al.Incidence and predictors of right ventricular pacing-induced cardiomyopathy. Heart Rhythm. 2014; 11: 1619-1625
- Kusumoto, F. et al (2018). 2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Circulation, 140(8), 382–482.
- Scherbak D, Hicks GJ. Left Bundle Branch Block. [Updated 2021 Aug 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482167/?msclkid=4a9baa18a61111ec887814fcd2b3154c
- Strauss DG, Selvester RH, Wagner GS. Defining left bundle branch block in the era of cardiac resynchronization therapy. Am J Cardiol. 2011 Mar 15;107(6):927-34. doi: 10.1016/j.amjcard.2010.11.010. PMID: 21376930.

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