Normal, Skipped, or Irregular Heart Beats: Does my Heart Rate Determine My Fate?

Gregory M Marcus, MD, MAS

Professor of Medicine

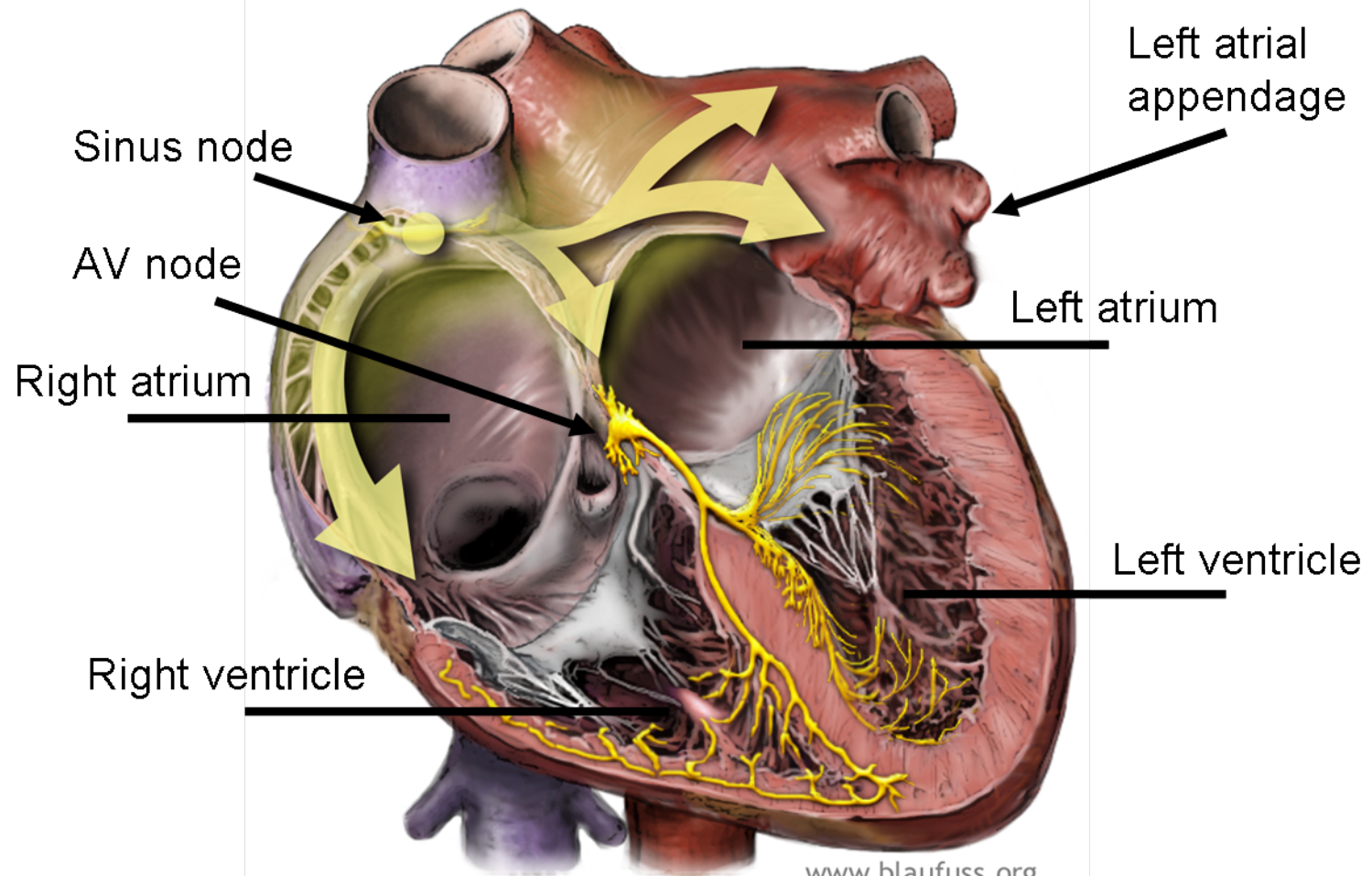University of California, San Francisco

Disclosures

- Research:
  - NIH
  - PCORI
  - TRDRP
  - Medtronic
  - Jawbone
  - Eight Sleep
  - Baylis
- Consulting and Equity:
  - InCarda Therapeutics
  - Talaria Therapeutics

Disclaimer

- This is a lot of information
- Many of my individual slides are full lectures (if not deserve their own courses and textbooks)
- I will hit the highlights
- When not to worry versus when to do something (more relevant with new wearable technologies)
- I am happy to answer more detailed questions at the end

Normal Sinus Rhythm

Sinus node

AV node

Right atrium

Right ventricle

Left atrial appendage

Left atrium

Left ventricle

www.blaufuss.org

Normal Heart Rate?

- Conventional answer:
  - 60-100 beats per minute
- How to check your heart rate
  - Find your pulse (wrist or neck—wrist preferred)
  - Count for a minute, or count for 15 seconds and multiply by four

Normal Heart Rate?

- Let's break down this 60-100 beats per minute

  - Implies lower than 60 (called "bradycardia") is a problem

  - Implies that faster than 100 (called "tachycardia") is a problem

- Cut to the chase: the great majority of the time, heart rates <60 or >100 are NORMAL

What determines the heart rate?
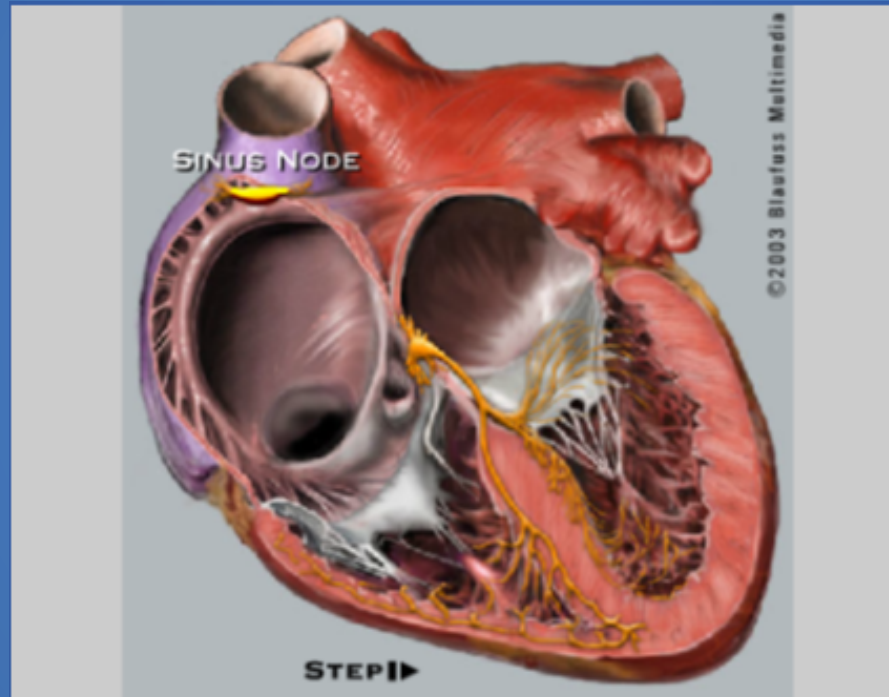
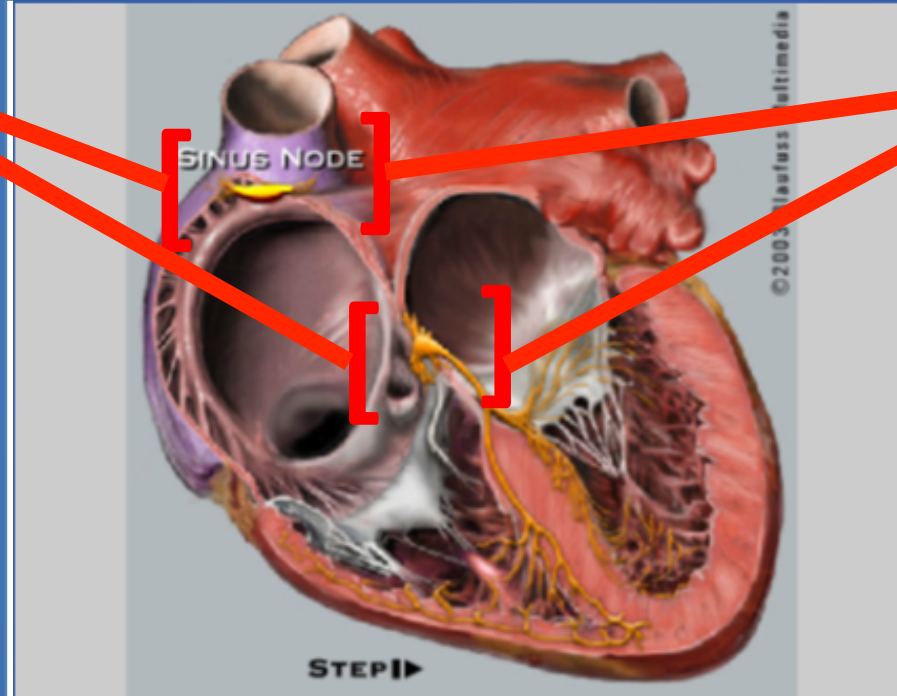# The autonomic nervous system

Heart Rate Too Fast?

- Faster than 100 beats per minute:
  - Normal—HEALTHY/ EXPECTED– if exercising or nervous or excited

- What number is too fast?
  - Generally if develop symptoms
    - Feeling faint, fatigued, or out of breath
      - Out of proportion to activity!

- Is there a number that is too fast even if feeling well?
  - Uncertain, perhaps >120 beats per minute 24 hours a day for weeks on end

Heart Rate Too Fast?

- Inappropriate sinus tachycardia
  - Cause remains unclear
  - Commonly seen in healthcare workers
  - In some, may be related to awareness of heart rate and "correct" heart rate
    - Oftentimes, trying to ignore heart rate helps
  - Ivabradine may help

Heart Rate Too Slow?

- There is no number per se that is "too slow"
  - Generally if develop symptoms
    - Pass out or feeling faint, fatigued, or out of breath

Heart Rate Too Slow?

- The most common cause of passing out:
  - Vasovagal syncope
  - The diagnosis is made by the history
  - Generally benign
  - Rarely a pacemaker may help
  - Rarely other drugs are needed

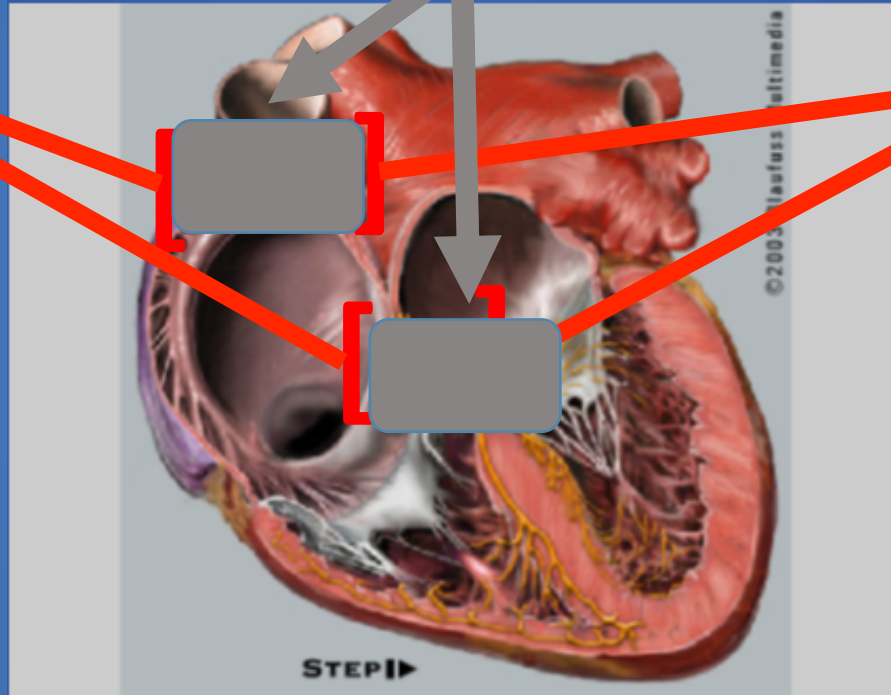# Another cause of a slow heart rate

SCAR TISSUE
(FIBROSIS)

The sympathetic
nervous system

AKA:
Adrenaline
Fight or Flight

Exercise
Anxiety
Excitement

The
parasympathetic
nervous system

AKA:
Vagal tone

Resting/ Sleeping
Eating/ Digesting

Why does scar tissue form in the conduction system?

Characteristic	Study Population, No. (%)		P Value[b]
	No Disease (n = 20 780)	Incident Disease[a] (n = 1114)	
Age, mean (SD), y	66.3 (7.3)	68.3 (7.2)	<.001
Female sex	8892 (45.2)	354 (31.8)	<.001
Race or ethnicity			
White non-Hispanic	10 221 (52.0)	712 (63.9)	
White Hispanic	2606 (13.3)	127 (11.4)	<.001
Black	6491 (33.0)	264 (23.7)	
Other[c]	348 (1.8)	11 (1.0)	
BMI, mean (SD)	29.8 (6.1)	29.8 (5.9)	.85
Current smoker	4264 (21.7)	230 (20.6)	.75
Prior antihypertensive treatment	17 782 (90.4)	1021 (91.7)	.39
Aspirin use	7407 (38.0)	494 (44.6)	<.001
Diabetes	7312 (39.4)	447 (43.0)	.03
Coronary heart disease	4832 (24.8)	375 (34.0)	<.001
Left ventricular hypertrophy	1077 (5.5)	134 (12.0)	<.001
GFR, mean (SD), mL/min/1.73 m^2	78.0 (18.8)	76.3 (19.3)	.002
Serum potassium level, mean (SD), mEq/L	4.30 (0.50)	4.35 (.49)	.005
Cholesterol level, mean (SD), mg/dL			
Total	216.0 (42.3)	213.4 (43.3)	.03
HDL	46.6 (14.7)	44.3 (13.9)	<.001
LDL	135.9 (36.5)	134.0 (35.0)	.03

Why does scar tissue form in the conduction system?

| AV block, all (n=58)		Hazard ratio*	(95% CI)	p
← lower risk of AV block higher risk of AV block →				
Age, years		1.19 †	(1.05 - 1.40)	0.02
Sex, male		1.72	(1.00 - 2.94)	0.051
Systolic blood pressure, mmHg		1.22 ‡	(1.07 - 1.40)	0.002
Myocardial infarction		2.46	(0.88 - 6.86)	0.09
Congestive heart failure		2.79	(0.90 - 8.72)	0.08
Cholesterol, mmol/l		1.18	(0.99 - 1.42)	0.07
Fasting glucose, mmol/l		1.18	(1.06 - 1.31)	0.003
PR interval		1.23 §	(1.13 -1.34)	<0.0001
Right bundle branch block		16.88	(6.79 - 41.98)	<0.0001
Left bundle branch block		12.71	(3.00 -53.88)	<0.0001

Kerola et al. American Heart Association Scientific Sessions, 2018

When do we treat slow or blocked rhythms due to scar tissue?

- If in the sinus node, we call it:
  - Sick sinus disease, sinus node dysfunction
  - TREAT FOR SYMPTOMS
- If in the AV node/ His-Purkinje system
  - Heart block (second degree, third degree, complete, high-grade)
  - Generally treat for evidence of sufficiently severe scar tissue here even if no symptoms (but most are symptomatic)

How do we treat slow or blocked rhythms due to scar tissue?

- With a pacemaker
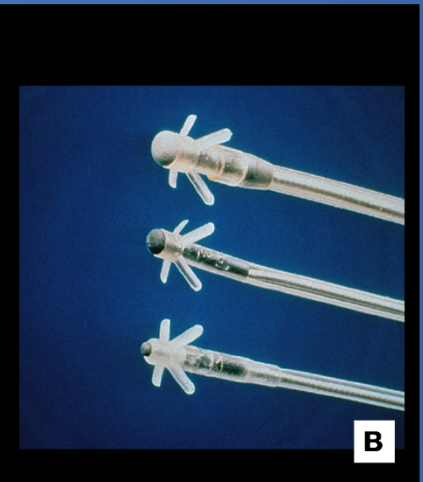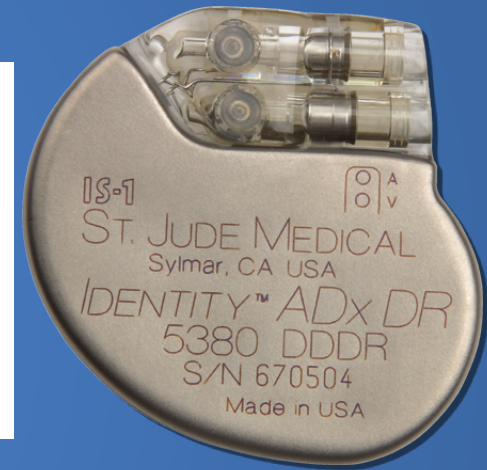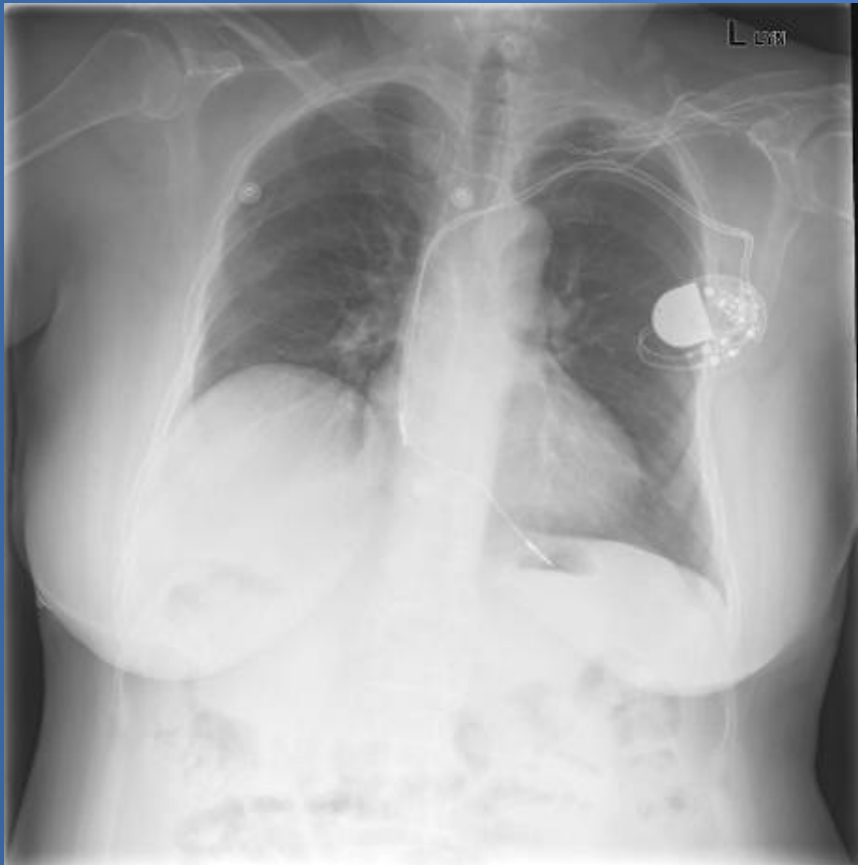
Skipped Beats

- Every muscle cell in the heart has the capability to beat on its own
- Sometimes a cell or group of cells likes to get ahead of everyone else

Skipped Beats

- Every muscle cell in the heart has the capability to beat on its own
- Sometimes a cell or group of cells likes to get ahead of everyone else

Premature Atrial Contractions

- Also called PACs
- Very common
- May or may not cause symptoms
- Generally nothing to do or worry about
- Spectrum of frequency

Atrial Ectopy as a Predictor of Incident Atrial Fibrillation
A Cohort Study

Thomas A. Dewland, MD; Eric Vittinghoff, PhD, MPH; Mala C. Mandyam, MD; Susan R. Heckbert, MD, PhD; David S. Siscovick, MD, MPH; Phyllis K. Stein, PhD; Bruce M. Psaty, MD, PhD; Nona Sotoodehnia, MD; John S. Gottdiener, MD; and Gregory M. Marcus, MD, MAS

Researchers at the University of California, San Francisco, reported this month in Annals of Internal Medicine that people with a high rate of premature atrial contractions, which can be detected by a Holter monitor worn for 24 hours, face a significantly increased risk of developing A-fib. Dr. Gregory M. Marcus, the senior author and director of clinical research at U.C.S.F.'s cardiology division, theorized that eradicating these premature contractions with drugs or a procedure that destroys the malfunctioning area of the heart may reduce the risk of the rhythm disorder.

Premature Atrial Contractions

- What to do?
  - Most of the time→ nothing (reassurance)
  - Symptoms: medicines or catheter ablation
  - Risk of atrial fibrillation:
    - Needs more research
    - Currently evaluating if the particular type of PAC may be important

Premature Ventricular Contractions
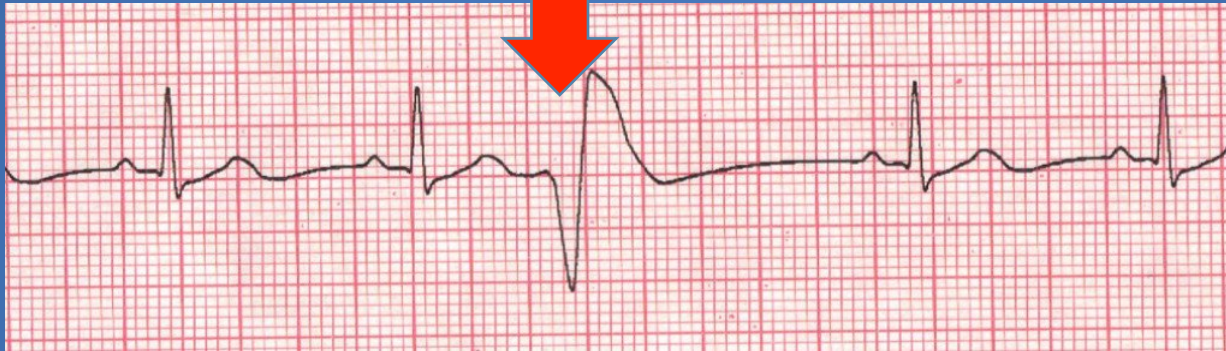
- Also called PVCs
- Very common
- May or may not cause symptoms
- Generally nothing to do or worry about
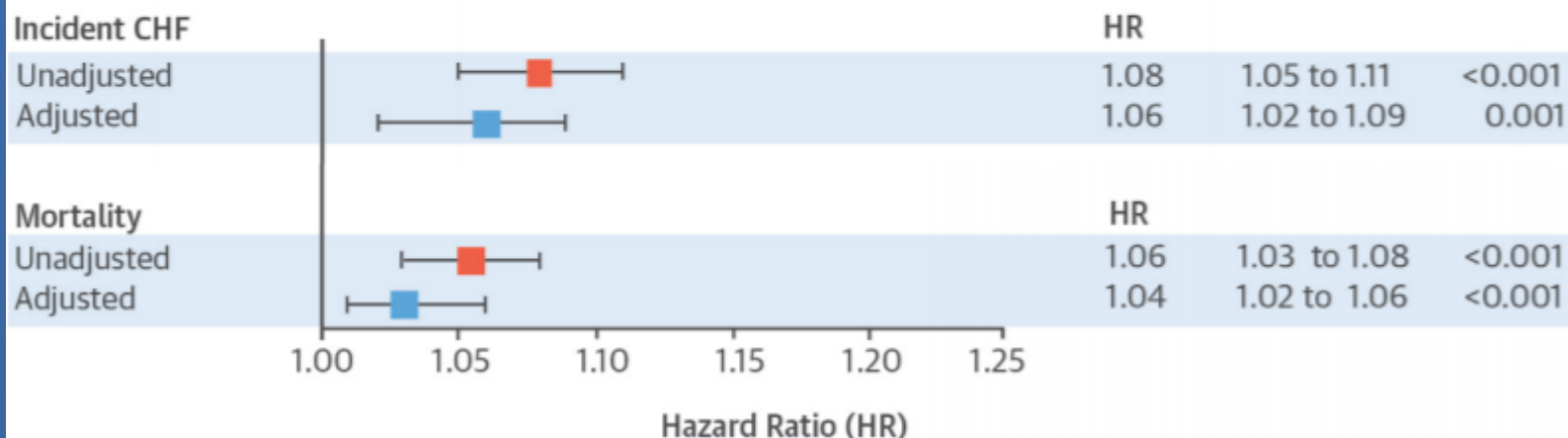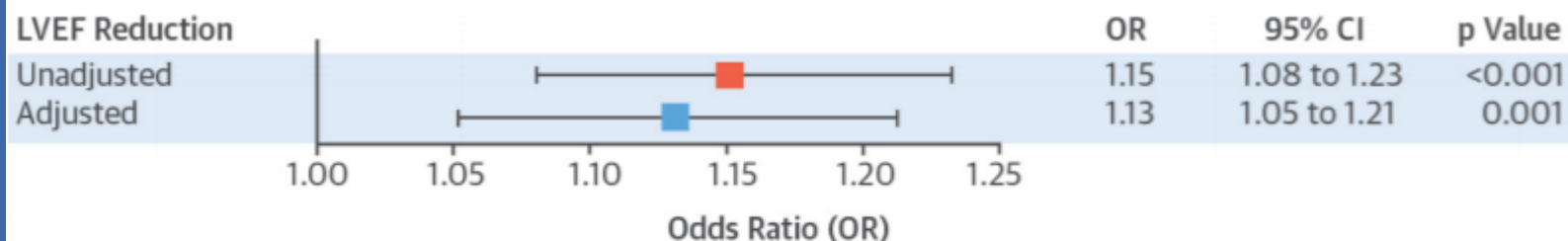- Spectrum of frequency

Premature Ventricular Contractions

THIS beat is where the symptoms are often felt "Frank-Starling" mechanism

• Poorly perfused PVCs may not result in a pulse and may present as pseudo-bradycardia

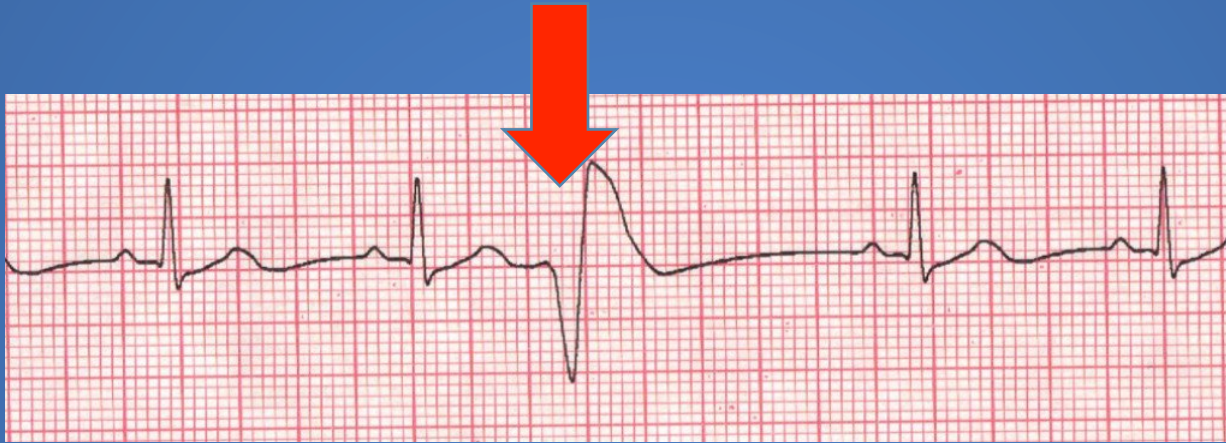# Ventricular Ectopy as a Predictor of Heart Failure and Death

Jonathan W. Dukes, MD,* Thomas A. Dewland, MD,† Eric Vittinghoff, PhD, MPH,‡ Mala C. Mandyam, MD,§ Susan R. Heckbert, MD, PhD,‖ David S. Siscovick, MD, MPH,‖¶ Phyllis K. Stein, PhD,# Bruce M. Psaty, MD, PhD,‖**†† Nona Sotoodehnia, MD,‖‡‡ John S. Gottdiener, MD,§§ Gregory M. Marcus, MD, MAS*

LVEF Reduction	OR	95% CI	p Value
Unadjusted	1.15	1.08 to 1.23	<0.001
Adjusted	1.13	1.05 to 1.21	0.001

Odds Ratio (OR)

Incident CHF	HR	95% CI	p Value
Unadjusted	1.08	1.05 to 1.11	<0.001
Adjusted	1.06	1.02 to 1.09	0.001

Mortality	HR	95% CI	p Value
Unadjusted	1.06	1.03 to 1.08	<0.001
Adjusted	1.04	1.02 to 1.06	<0.001

Hazard Ratio (HR)

Premature Ventricular Contractions

- What to do?
  - Most of the time→ nothing (reassurance)
  - Bothersome symptoms: medicines or catheter ablation

Premature Ventricular Contractions
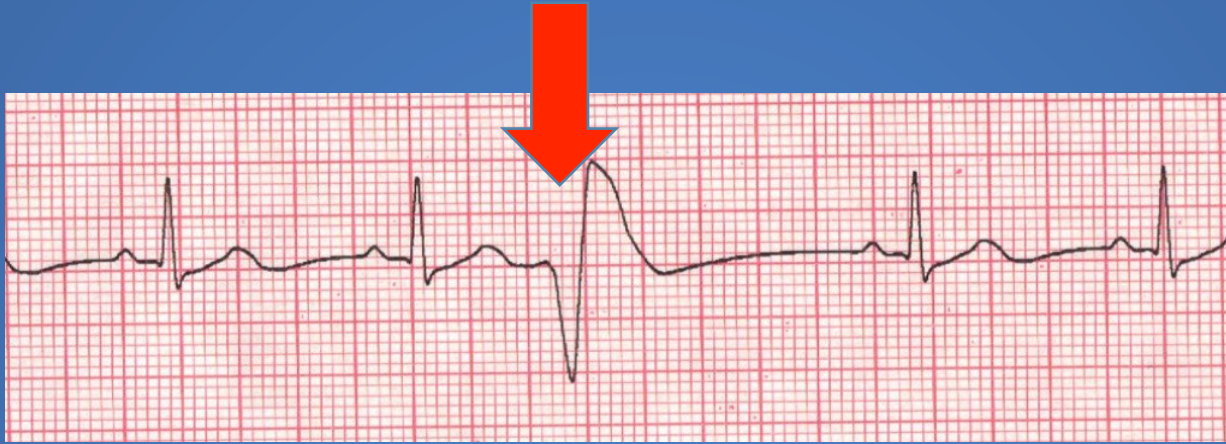
- What to do?
  - IF there is evidence the heart is weak AND there are a lot of PVCs (10-20% of all beats)→ catheter ablation
  - IF symptoms aren't too bothersome, heart is strong and PVCs are very frequent (10-20%)→ serial echocardiograms (eg, yearly)

How do you know if the heart is "weak"?

- An echocardiogram (ultrasound of the heart) is most common test to assess structure and function of the heart and heart valves
  - "Echo" for short
  - Not to be confused with "electrocardiogram" ("EKG" or "ECG" for short).
- MRI is becoming a more commonly utilized tool
  - Especially to look for tissue characteristics, like scar

EP Study and Catheter Ablation
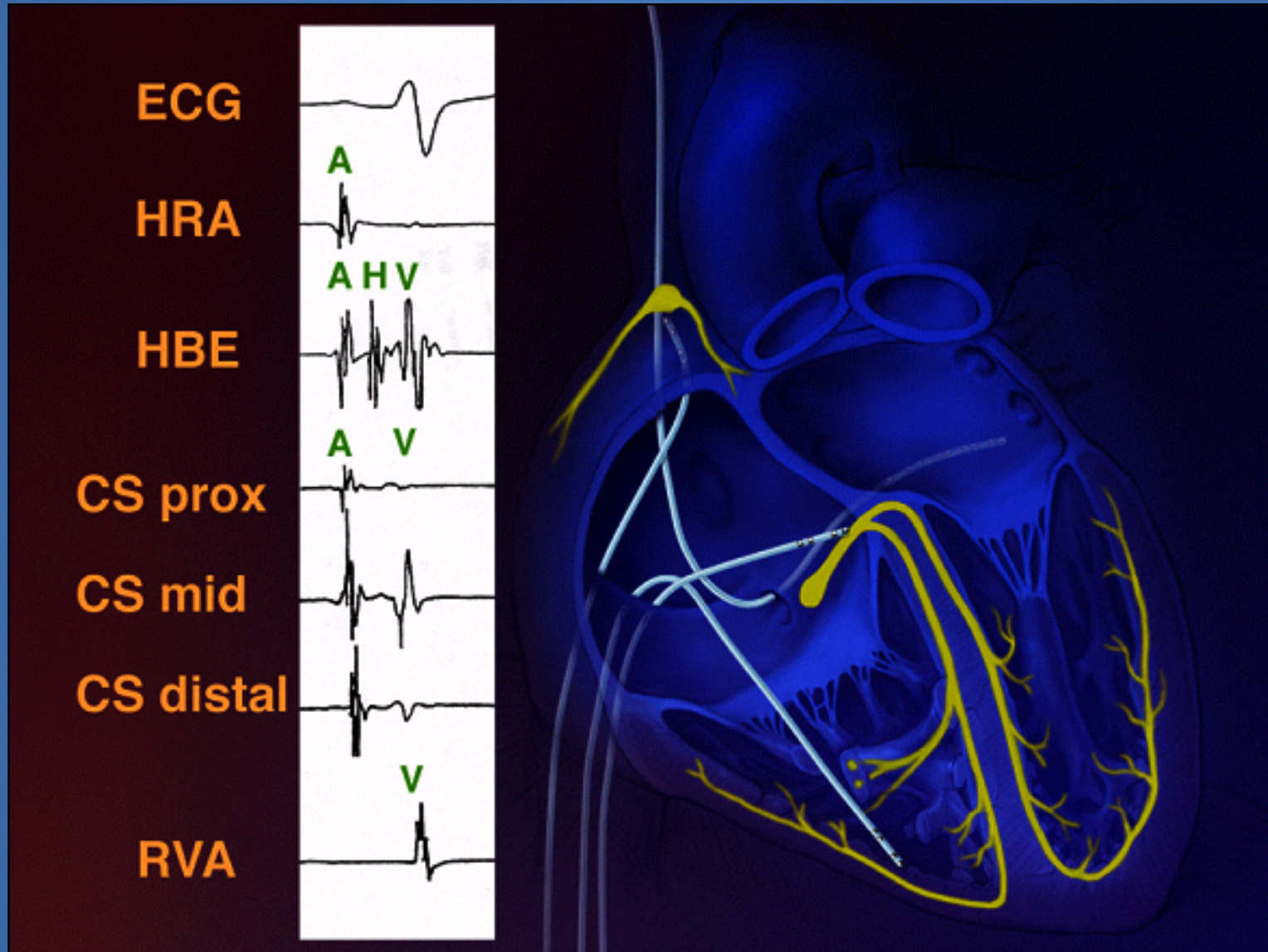
Catheter Ablation (of a PAC or atrial tachycardia)
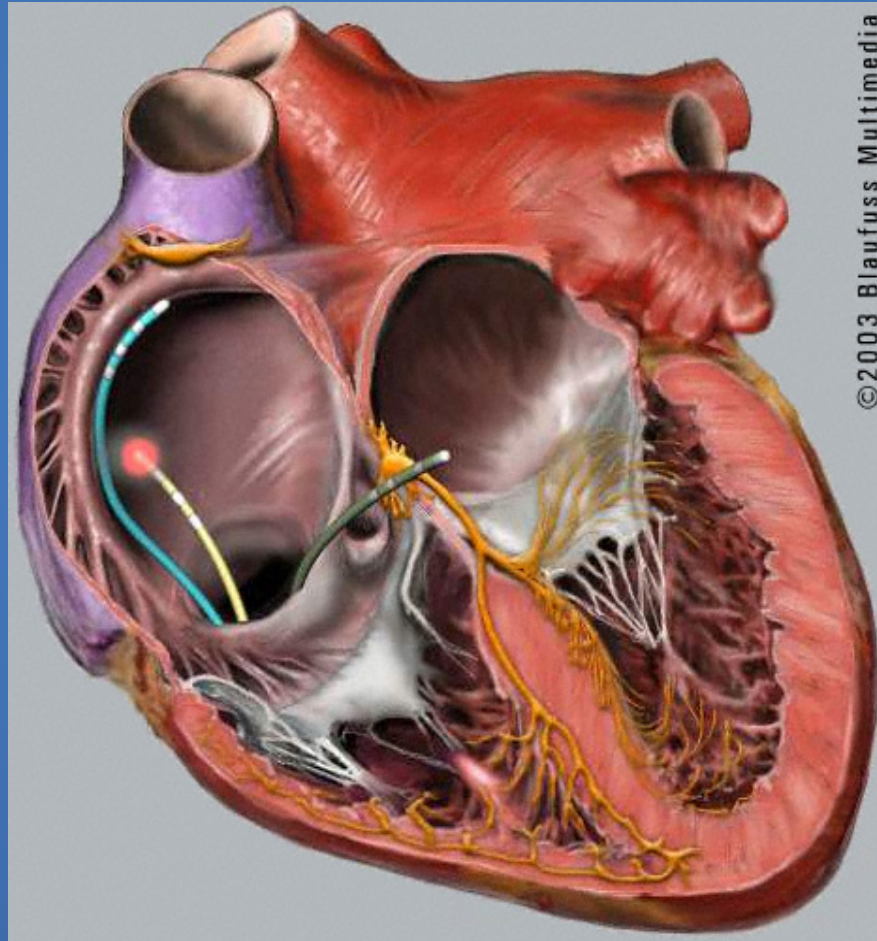
Atrial Tachycardia

- ≥ 3 of those PACs in a row
- "Sustained" means ≥ 30 seconds
- Extremely common to find when on ECG monitoring over a long period of time
- Rarely, patients may experience very bothersome atrial tachycardia, usually because it is longer in duration

Ventricular Tachycardia
AKA "VT"

- ≥ 3 of those PVCs in a row
- "Sustained" means ≥ 30 seconds
- Can be particularly bothersome if longer in duration, but can see runs of "nonsustained ventricular tachycardia"

Ventricular Tachycardia
AKA "VT"

- Can be benign if the heart is structurally normal
- If the heart is weak or a patient has had a heart attack, this can be a sign that there is a risk of sudden death

Ventricular Fibrillation AKA "VF"

- The ventricles are being activated in an extremely fast, disorganized fashion
- The heart is not able to pump blood
- VT can degenerate into VF in sick hearts
- VF can occur due to an inherited syndrome (electrical or structural)
- The only way to treat VF is with a shock to the heart
- Symptoms are loss of consciousness and death

Prevention/ Treatment of VF

- Some drugs can reduce the risk for VF
  - Beta-blockers (metoprolol, carvedilol)
  - Amiodarone
- If a patient is felt to be at high enough risk for VF and there is no reversible cause (like in the setting of a heart attack or cocaine use)
  - Implantable Cardioverter-Defibrillator (ICD)

Implantable Cardioverter-Defibrillator (ICD)
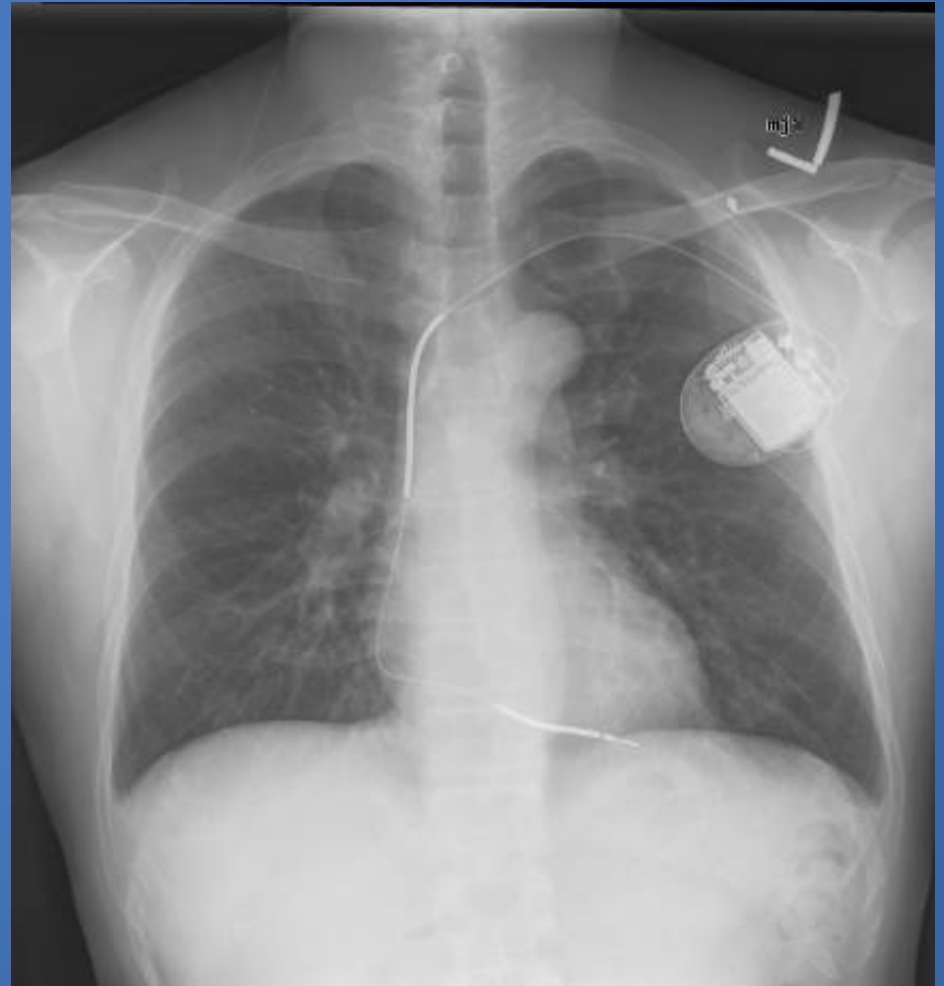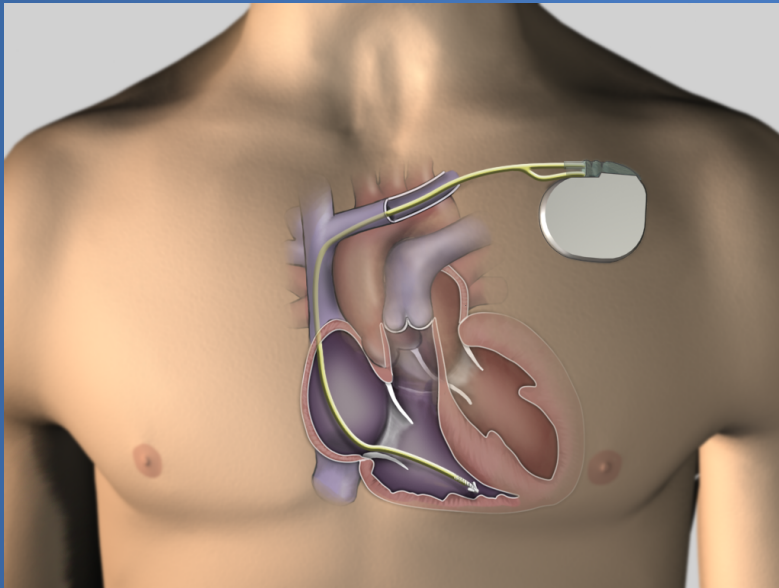
Last bits on VF

- Wait- do I have VF?
  - No
- Who is at risk?
  - MAYBE if a young family member has died suddenly without explanation ("heart attack" may have been VF)
  - MAYBE for patients who have had a heart attack or a weak heart
  - MAYBE for people who have passed out without warning, DURING exertion, or been injured due to passing out

Back to Symptomatic Arrhythmias: Supraventricular Tachycardia (SVT)
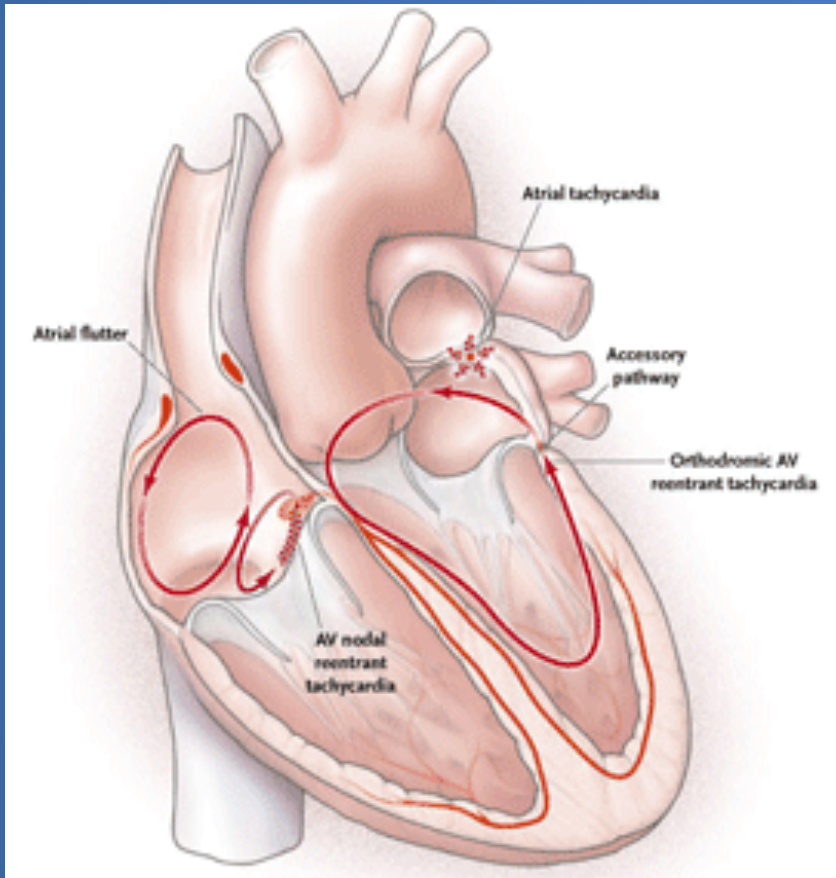
- Abrupt rapid heart beat, often with:
  - Sense of heart beating out of chest
  - Shortness of breath
  - Feeling exhausted
  - Feeling faint
  - NOT SUBTLE

Back to Symptomatic Arrhythmias: Supraventricular Tachycardia (SVT)

Vagal Manuevers

- **Carotid sinus massage**

- **"Valsava" (bearing down)**
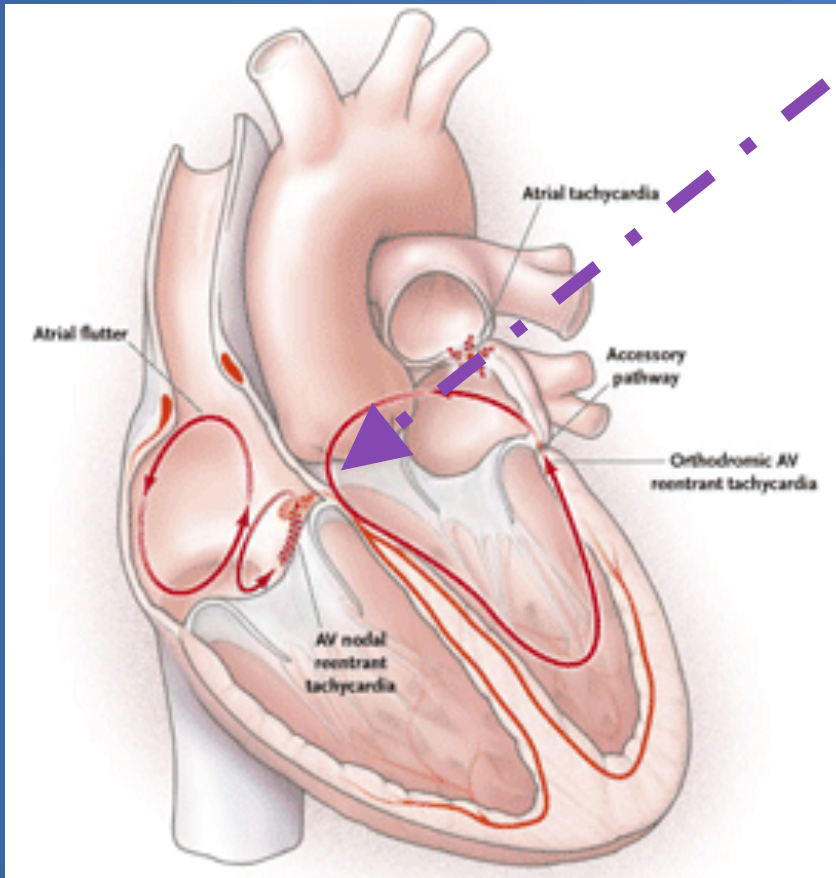
Back to Symptomatic Arrhythmias: Supraventricular Tachycardia (SVT)
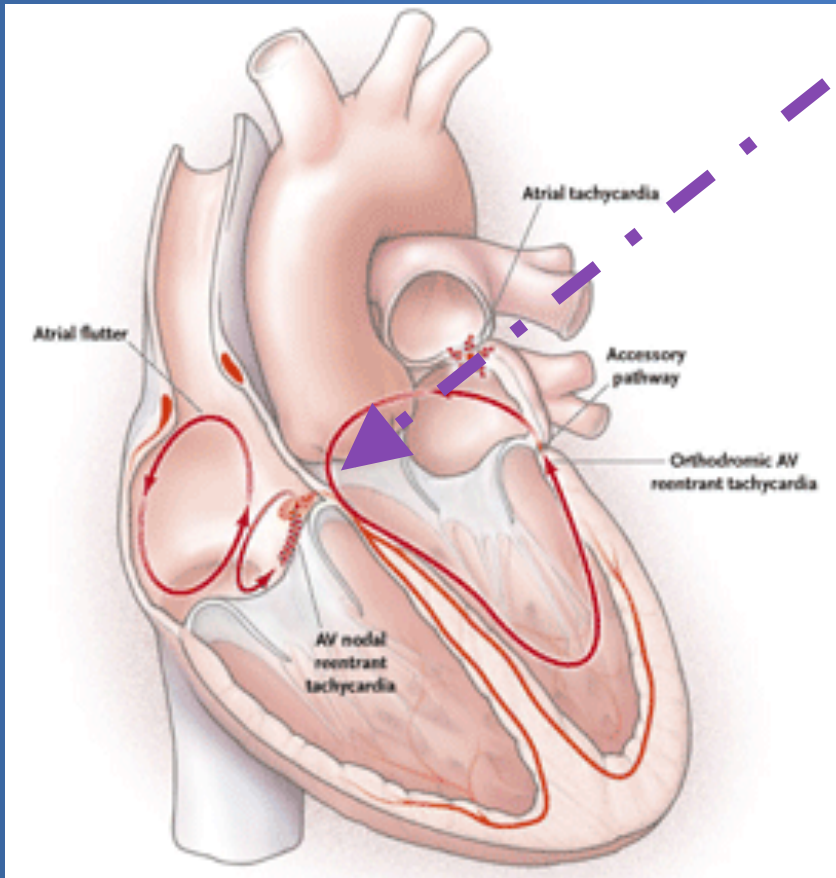
Drugs

- **ADENOSINE (commonly given by EMTs and in ERs)**

- **Beta-blockers- short or longterm**

- **Calcium channel blocker- short or longterm**

Catheter Ablation can cure a "REAL" SVT about 95% of the time

© 2003 Blaufuss Multimedi
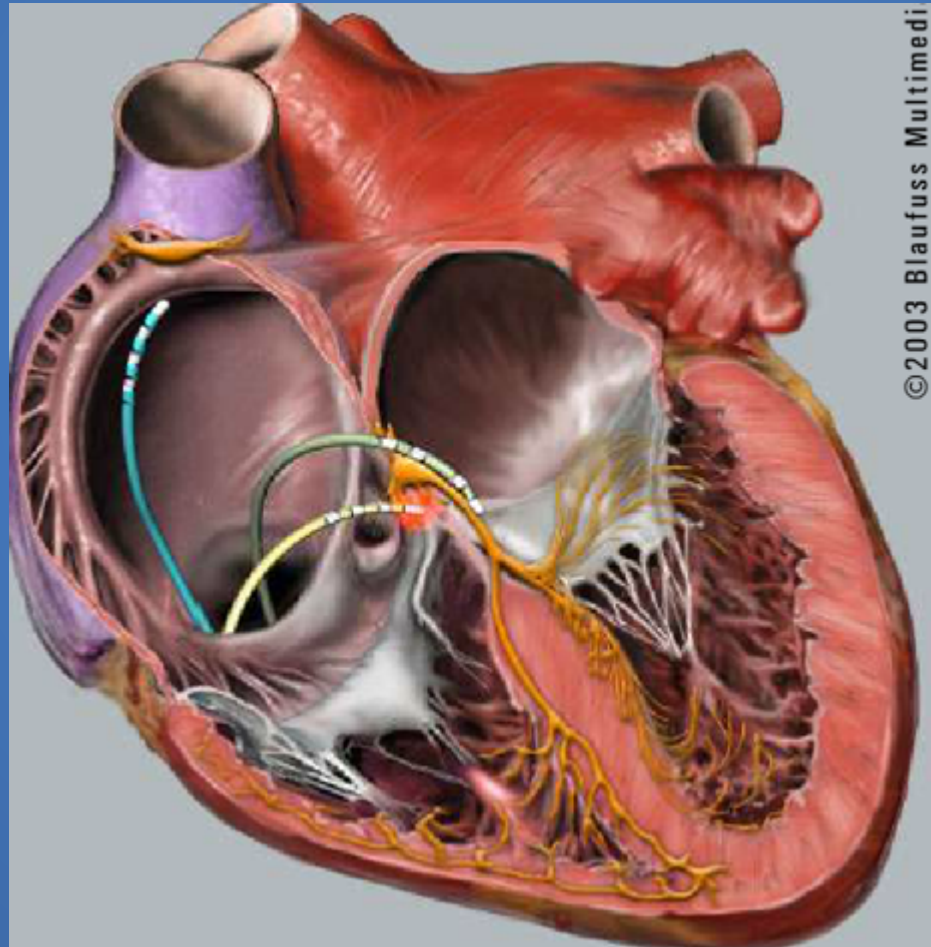
Catheter Ablation can cure a "REAL" SVT about 95% of the time
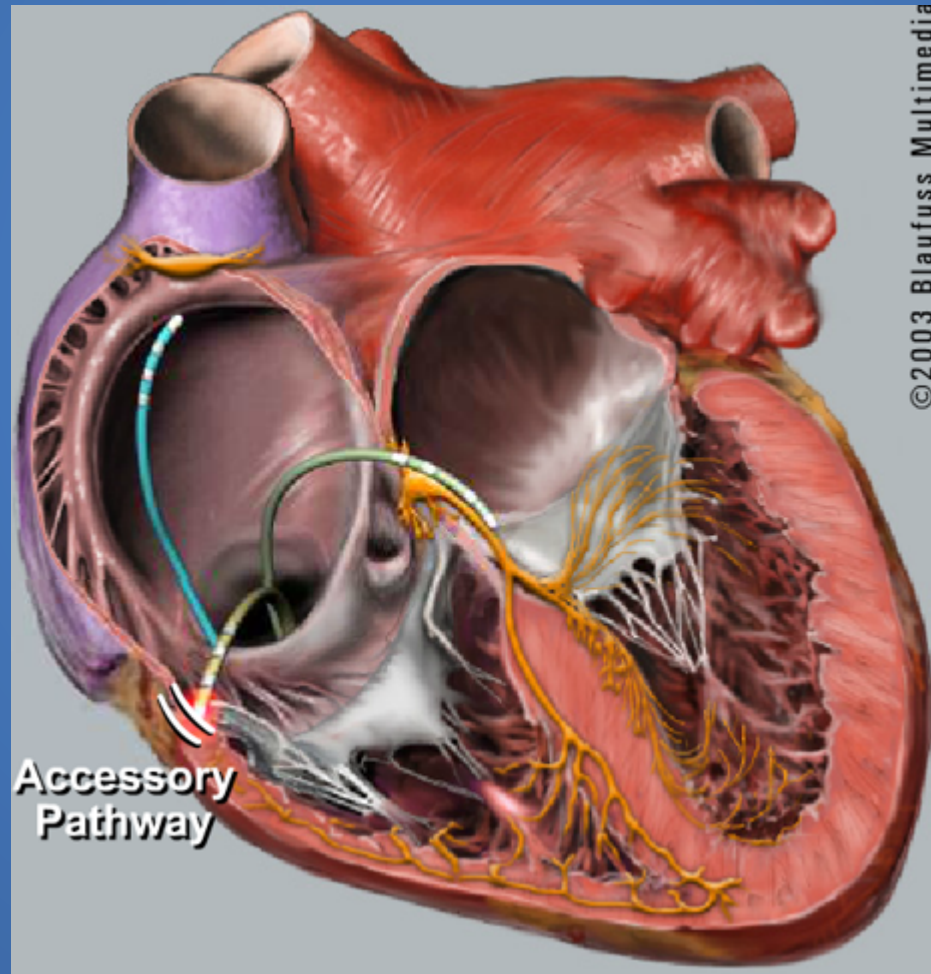
Wolff-Parkinson-White (WPW)

Atrial Fibrillation

www.blaufuss.org
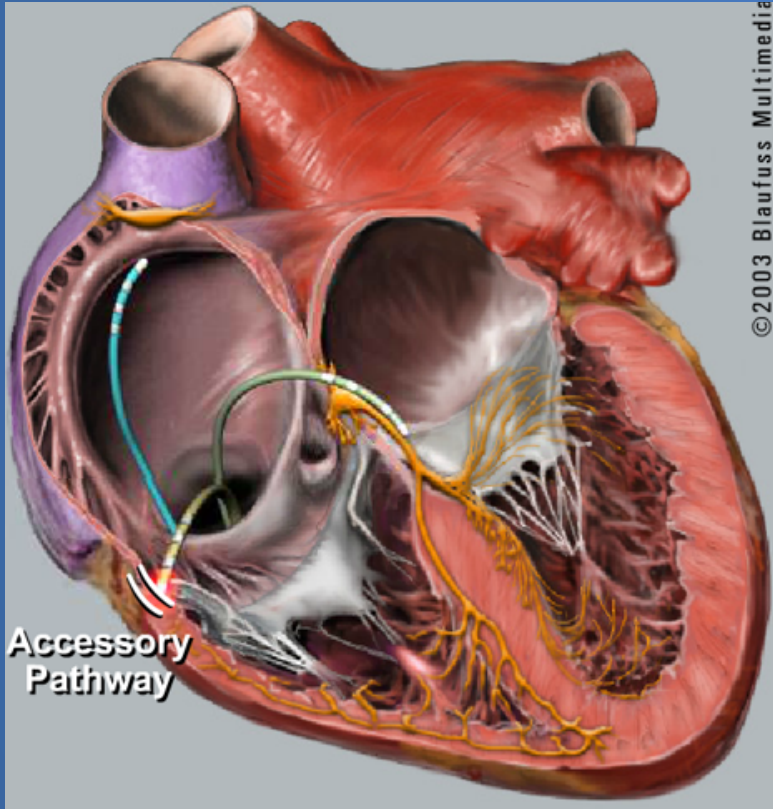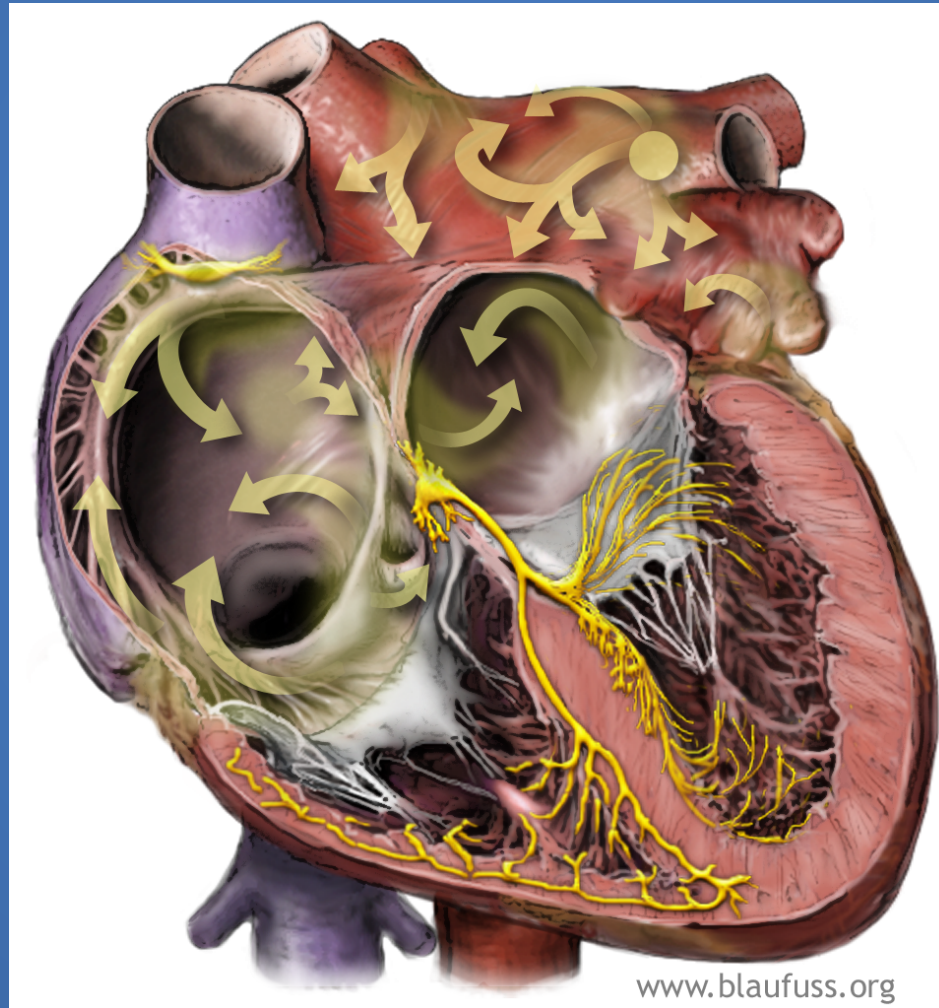
Risk Factors for Atrial Fibrillation

- Increasing age
- Male
- Caucasian Race
- Hypertension
- Heart failure
- Diabetes
- Coronary artery disease
- Alcohol
- Increased BMI
- Obstructive sleep apnea and sleep disruption
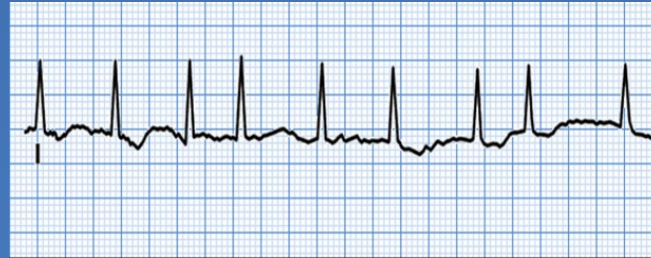- Hyperthyroidism

Symptoms of Atrial Fibrillation

- Note: can come and go ("paroxysmal") or be there all the time ("persistent")
- Fatigue
- Shortness of breath
- Feeling faint
- Other feeling of being "off"
- Many others
- CAN BE ASYMPTOMATIC

Atrial Fibrillation and Stroke
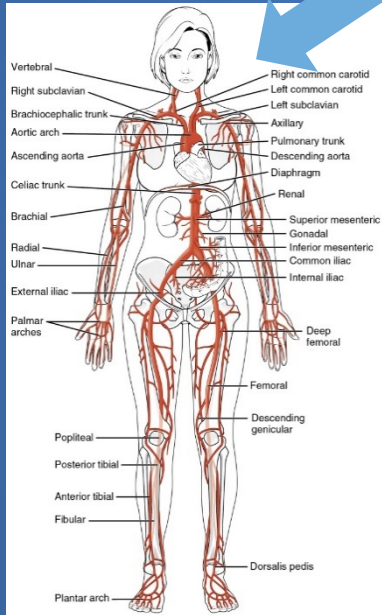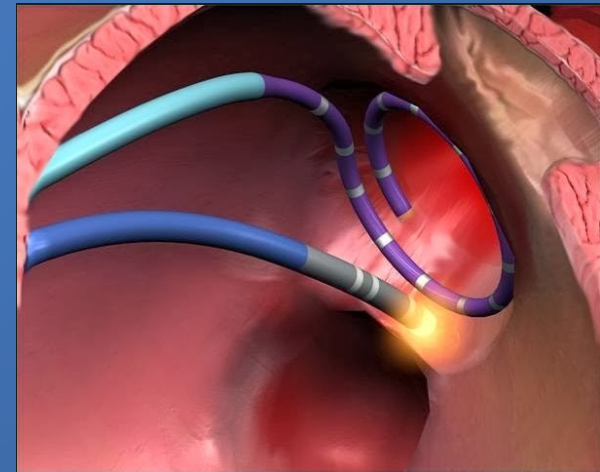

www.blaufuss.org

Thrombus

LEFT ATRIUM
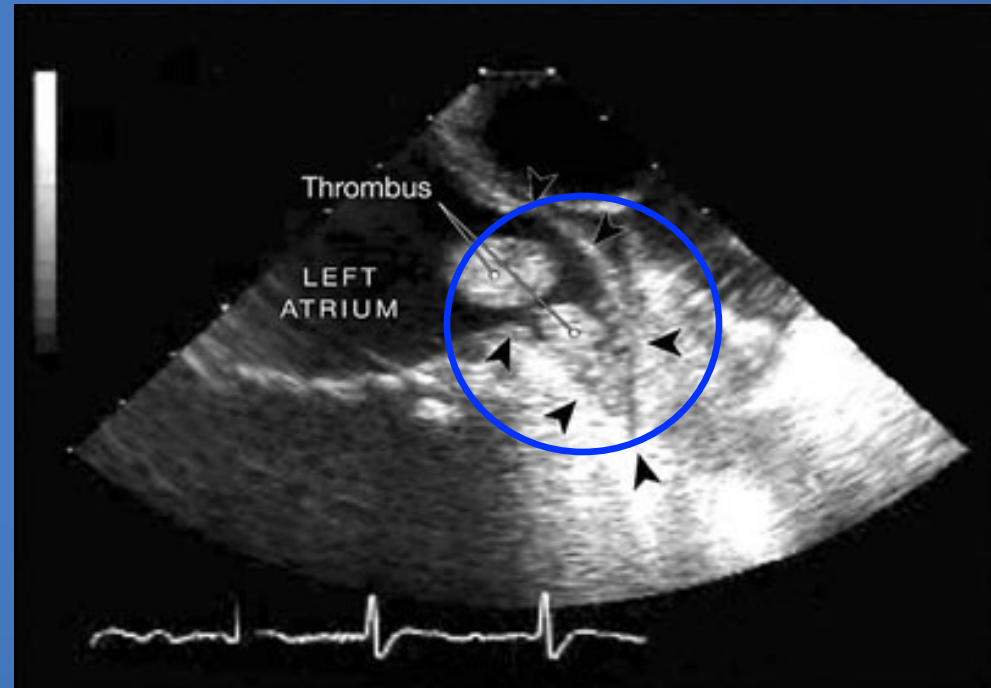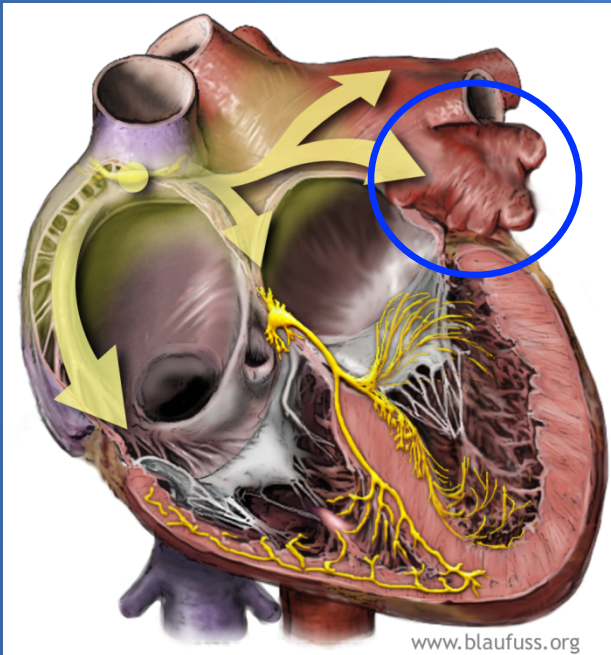
Goals of Treating Atrial Fibrillation

2. Avoid prolonged fast ventricular rates

3. Improve quality of life

1. Prevent thromboembolism

CARDIOVERSION
Drugs: Flecanide
Propafenone
Sotalol
Dofetilide
Dronaderone
Amiodarone

Prevention of Thromboembolism

CHA$_2$DS$_2$-VASc acronym	
Congestive HF	1
Hypertension	1
Age $\geq$75 y	2
Diabetes mellitus	1
Stroke/TIA/TE	2
Vascular disease (prior MI, PAD, or aortic plaque)	1
Age 65–74 y	1
Sex category (i.e., female sex)	1
Maximum Score	9

Prevention of Thromboembolism

- Warfarin = Coumadin

Novel Oral Anticoagulants (NOACs)

Or Direct Oral Anticoagulants (DOACs)

- Dabigatran = Pradaxa

- Rivaroxaban = Xarelto

- Apixiban = Eliquis

- Edoxaban = Savaysa

What about those scary adds on TV related to litigation?

- There is a risk of bleeding with these
- When indicated, the risk of NOT taking them far exceeds the risk of taking them
- No one alerts the presses when a patient comes to the ED bleeding because of warfarin
- Patients don't call in the middle of the night to thank you because they didn't have a stroke

Oral Anticoagulant Therapy Prescription in Patients With Atrial Fibrillation Across the Spectrum of Stroke Risk

Insights From the NCDR PINNACLE Registry

Jonathan C. Hsu, MD, MAS; Thomas M. Maddox, MD, MSc; Kevin F. Kennedy, MS; David F. Katz, MD; Lucas N. Marzec, MD; Steven A. Lubitz, MD, MPH; Anil K. Gehi, MD; Mintu P. Turakhia, MD, MAS; Gregory M. Marcus, MD, MAS

Figure 2. Prevalence of Antithrombotic Therapies in Patients With Atrial Fibrillation (AF) Across the Spectrum of Stroke Risk by the CHADS$_2$ Score and the CHA$_2$DS$_2$-VASc Score
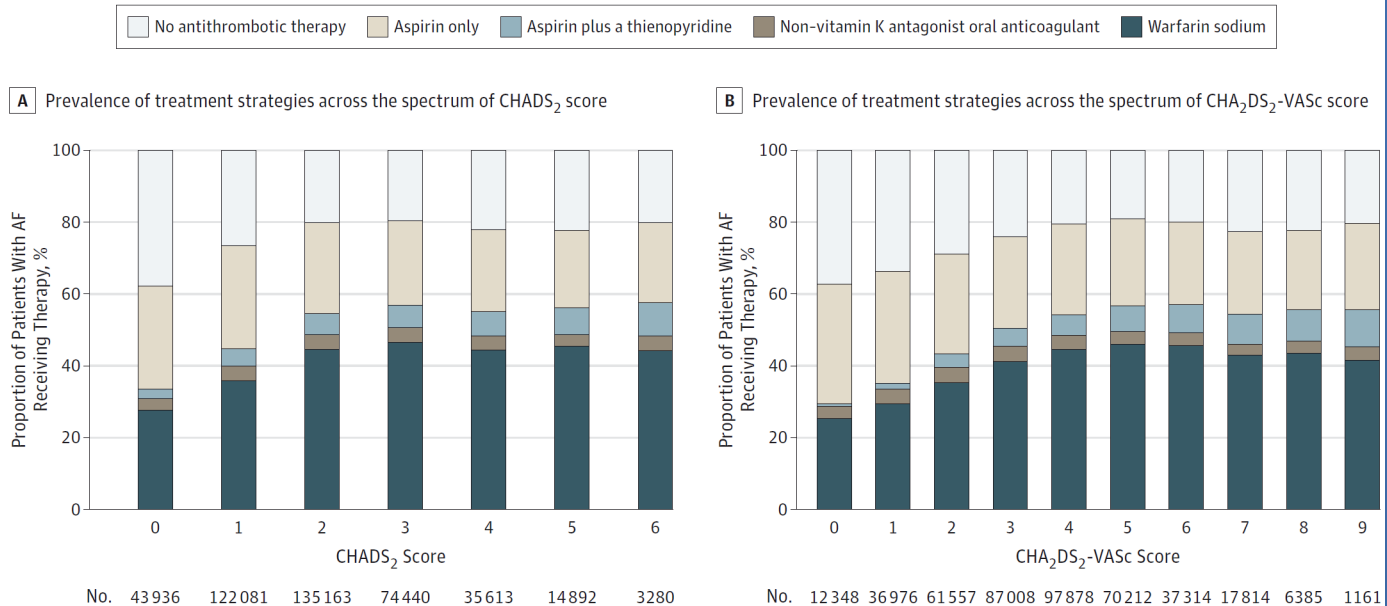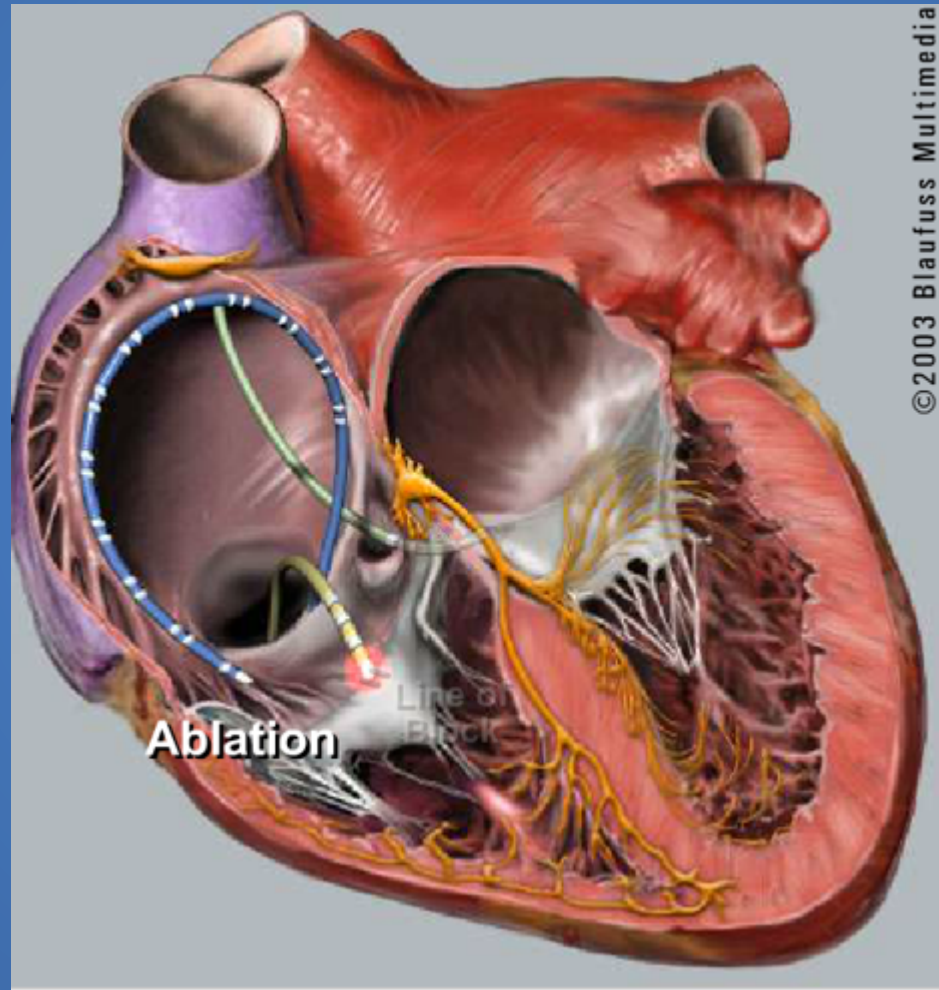
Ablation of Atrial Fibrillation

- Generally for symptoms
- The most effective way to suppress atrial fibrillation, but less effective than other ablation procedures
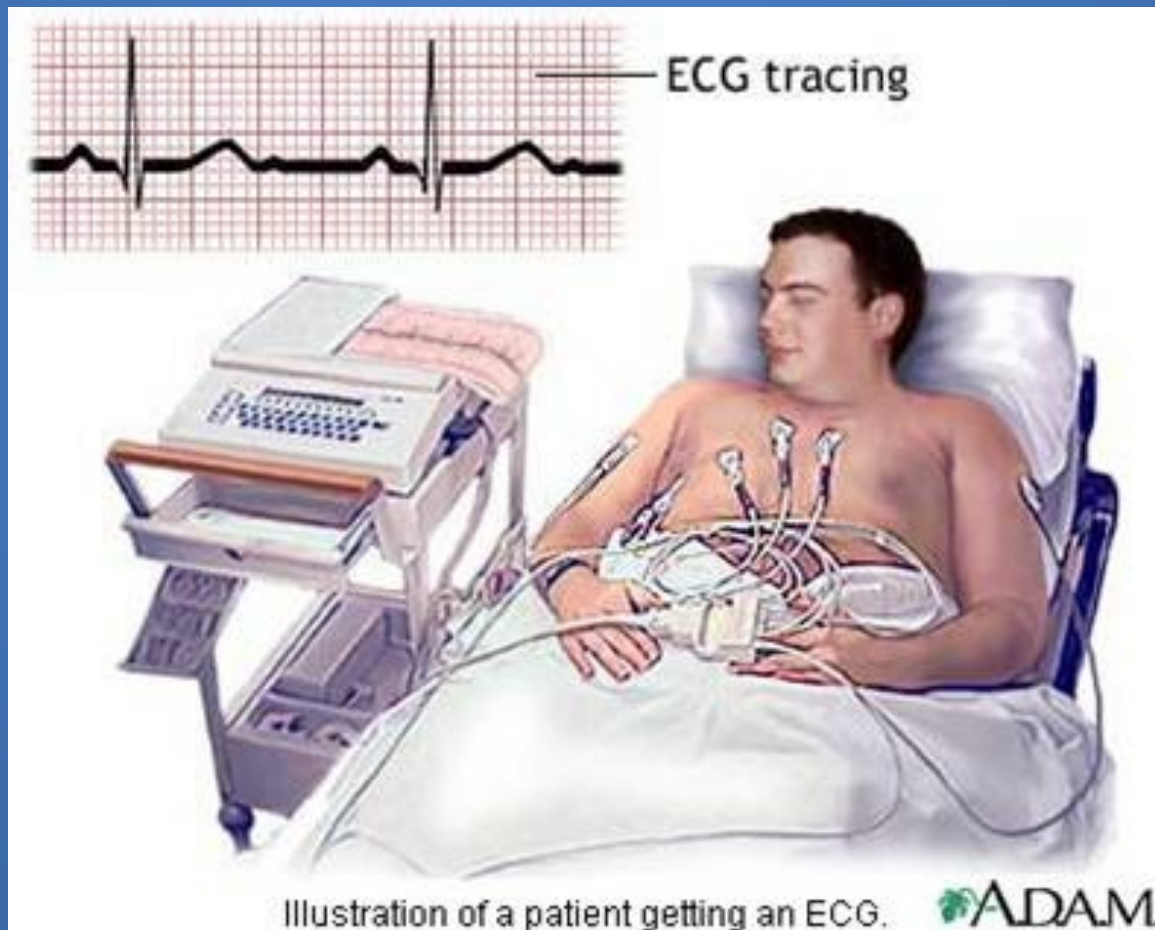
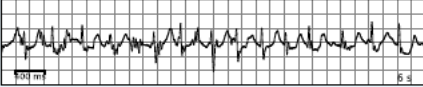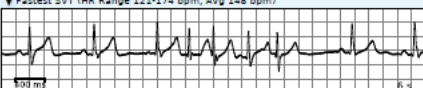# Ablation of Atrial Fibrillation
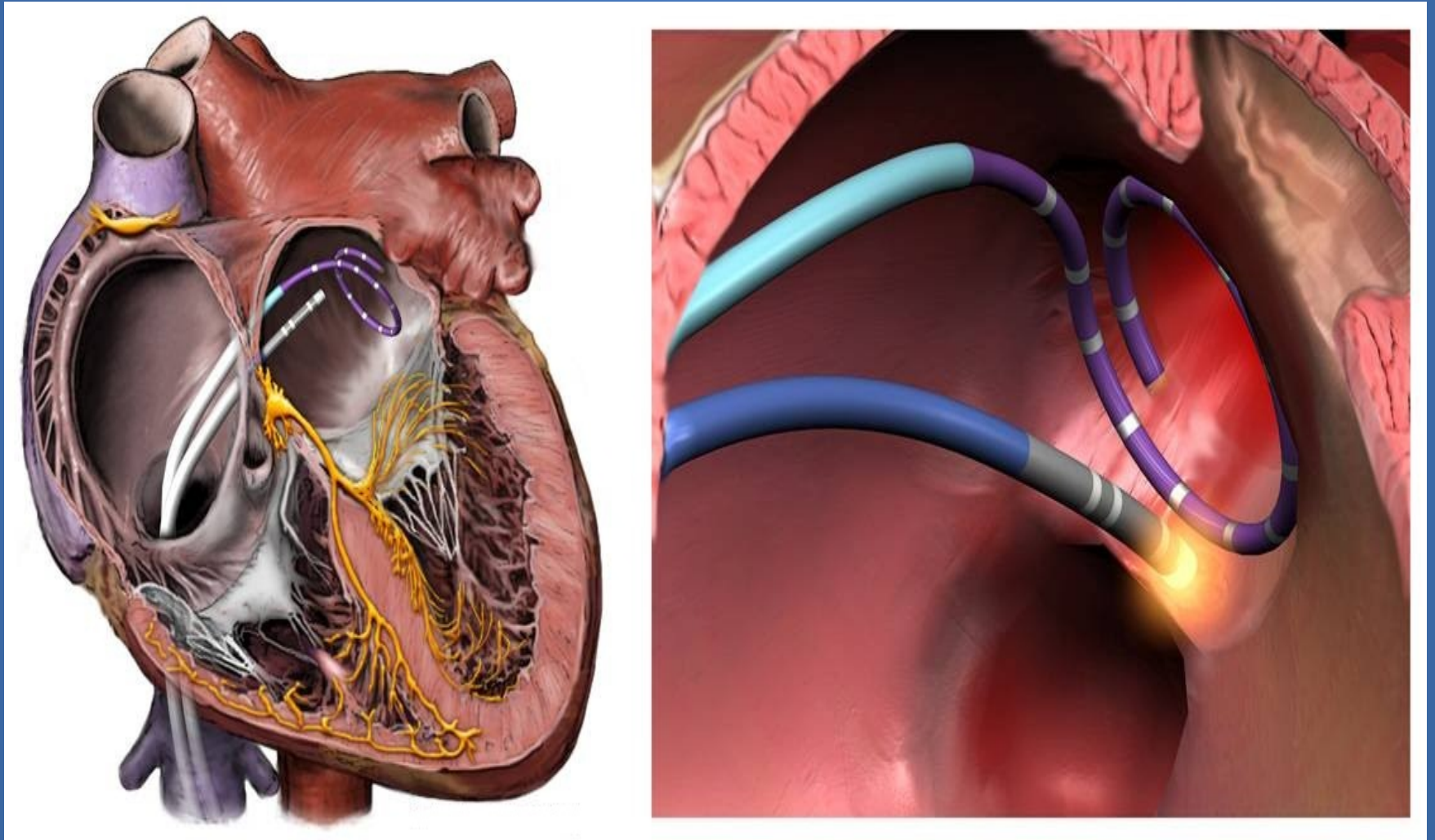
Atrial Flutter

Making a Diagnosis: Generally need to see the arrhythmia at the time it is happening

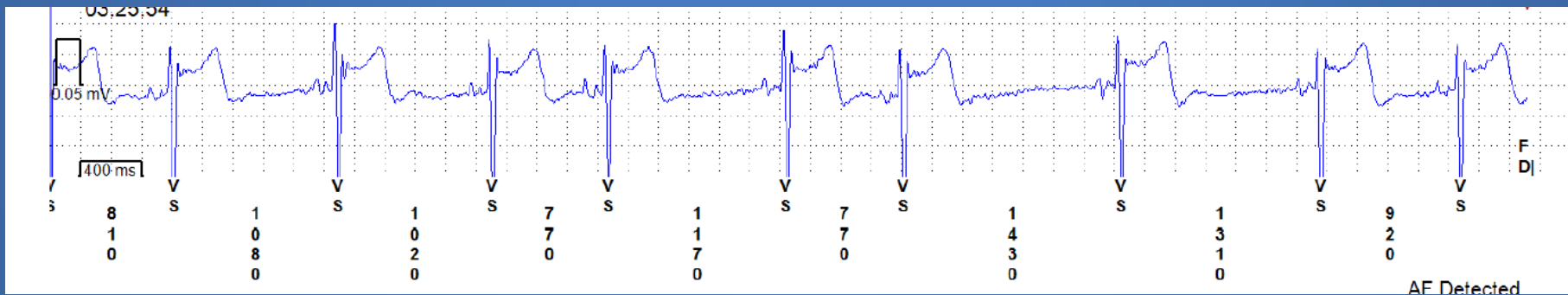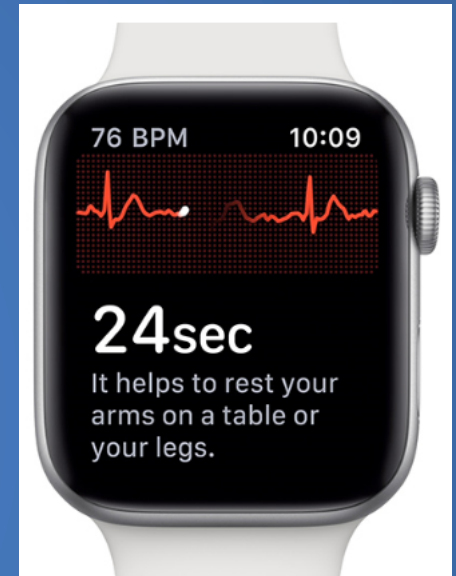Illustration of a patient getting an ECG. ADAM.

Atrial Fibrillation/Flutter

▼ Fastest AF/AFL (HR Range 96-171 bpm, Avg 129 bpm)

AF/AFL Burden
< 1%

Longest Duration
25 m 8 s

HR Range
62-171 bpm

Avg
97 bpm

Supraventricular Tachycardia (4 beats or more)

▼ Fastest SVT (HR Range 121-174 bpm, Avg 148 bpm)

Episodes
23

HR Range
78-174 bpm

Avg
129 bpm

Ventricular Tachycardia (4 beats or more)

None found

Pauses (3 secs or longer)

None found

AV Block (2nd° Mobitz II, 3rd°)

None found

Heart Rate

Overall			
	Max	**174 bpm**	04:08pm, 02/10
	Min	**43 bpm**	02:30am, 02/11
	Avg	**64 bpm**	

Sinus			
	Max	**121 bpm**	05:49pm, 02/12
	Min	**43 bpm**	02:30am, 02/11
	Avg	**64 bpm**	

Patient Events

Triggered Events: 3
Findings within ± 45 sec of Triggers:
Atrial Fibrillation/Flutter, Sinus Rhythm, Supraventricular Ectopic beat(s)

Diary Entries: 2
Findings within ± 45 sec of Entries:
Atrial Fibrillation/Flutter, Sinus Rhythm, Supraventricular Ectopic beat(s), Ventricular Ectopic beat(s)

Ectopics

	Rare <1%	Occasional 1% to <5%	Frequent 5%+
Supraventricular Ectopy (SVE/PACs)			
Isolated	Rare	<1.0%	
Couplet	Rare	<1.0%	
Triplet	Rare	<1.0%	
Ventricular Ectopy (VE/PVCs)			
Isolated	Rare	<1.0%	
Couplet	Rare	<1.0%	
Triplet	0		

Longest Ventricular Bigeminy Episode 28.3 s
Longest Ventricular Trigeminy Episode 8.7 s

Preliminary Findings

Patient had a min HR of 43 bpm, max HR of 174 bpm, and avg HR of 64 bpm. Predominant underlying rhythm was Sinus Rhythm. Borderline First Degree AV Block was present. 23 Supraventricular Tachycardia runs occurred, the run with the fastest interval lasting 4 beats with a max rate of 174 bpm, the longest lasting 16 beats with an avg rate of 134 bpm. Atrial Fibrillation/Flutter occurred (<1% burden), ranging from 62-171 bpm (avg of 97 bpm), the longest lasting 25 mins 8 secs with an avg rate of 89 bpm. Atrial Fibrillation was detected within +/- 45 seconds of patient triggered/diary event. Isolated SVEs were rare (<1.0%), SVE Couplets were rare (<1.0%), and SVE Triplets were rare (<1.0%). Isolated VEs were rare (<1.0%), VE Couplets were rare (<1.0%), and no VE Triplets were present. Ventricular Bigeminy and Trigeminy were present.

Final Interpretation

There were 3 triggered events with symptoms of skipped/irregular beats associated with sinus rhythm with rare premature atrial beats with episodes of atrial fibrillation vs atrial tachycardia. Atrial fibrillation/flutter vs atrial tachycardia was observed < 1% of the monitoring period. (AF/Fi vs ATach is difficult to differentiate with only single lead).

Injectable Loop Recorder

AliveCor Kardia and   AliveCor Kardia Band   Apple Watch

JAMA Cardiology | Original Investigation

Passive Detection of Atrial Fibrillation Using a Commercially Available Smartwatch

Geoffrey H. Tison, MD, MPH; José M. Sanchez, MD; Brandon Ballinger, BS; Avesh Singh, MS; Jeffrey E. Olgin, MD; Mark J. Pletcher, MD, MPH; Eric Vittinghoff, PhD; Emily S. Lee, BA; Shannon M. Fan, BA; Rachel A. Gladstone, BA; Carlos Mikell, BS; Nimit Sohoni, BS; Johnson Hsieh, MS; Gregory M. Marcus, MD, MAS

NORMAL SINUS RHYTHM

ATRIAL FIBRILLATION
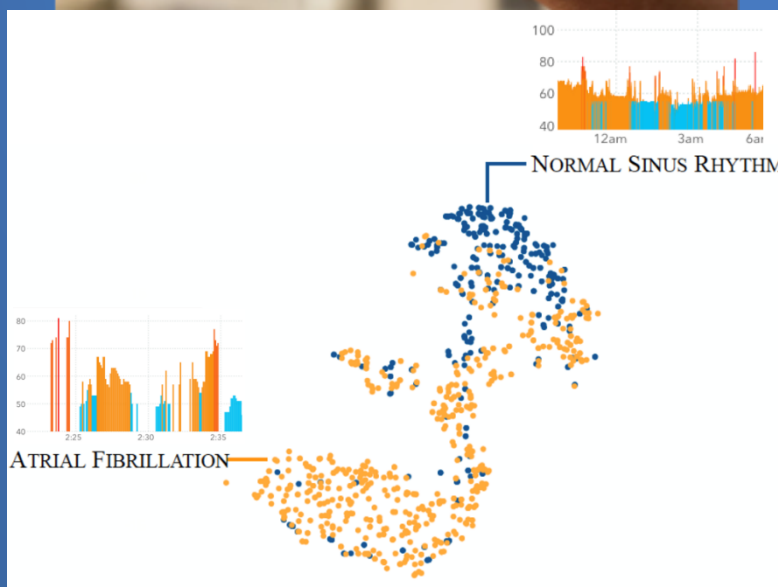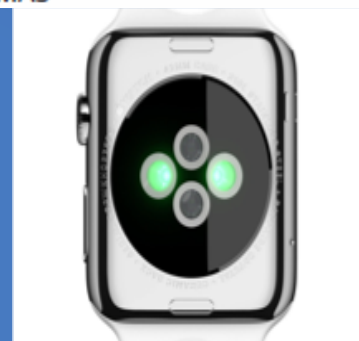
- In-person validation (n=51): c-statistic=0.97 (95% CI 0.94-1).
- Ambulatory validation (n=617): c-statistic=0.72 (95% CI 0.64-0.78) %)

Conclusions

- Generally no need to worry about an abnormal heart rate
  - We do something when patients do not feel well
  - It's good to exercise and intentionally raise your heart rate!
- Extra heart beats are common
  - Physicians generally treat for symptoms
  - Very frequent PVCs may warrant more follow-up
- Pacemakers work well for slow heart rates that clearly cause symptoms (GENERALLY NOT DUE TO ANY NUMBER PER SE)
- ICDs work well to save lives in those prone to ventricular fibrillation
- SVT, which results in severe symptoms, can be treated with medicines or cured with ablation

Conclusions

- Atrial fibrillation carries a risk for stroke and other "thromboembolic" complications that can be prevented by blood thinners

- Medicines and ablation can help improve quality of life in atrial fibrillation

- The diagnosis of an arrhythmia generally requires we catch it as it happens

- New wearable technologies will become more and more useful in helping to diagnose arrhythmias
  - Therefore, important to understand when not to worry and when to do something

Thank You