Penn State College of Medicine
Continuing Education

13th Annual Central PA Sports Medicine Symposium

Tuesday, June 10, 2025

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Any names or ages used on the upcoming slides are fictitious and not referring to an actual patient.

PennState College of Medicine

1

Cardiac Arrhythmias in Sports Medicine

Joe Andrie, MD
2025
Penn State Health Sports Medicine Symposium

2

What is an arrhythmia?

"Arrhythmos" in Greek

Meaning Irregular or unrhythmical

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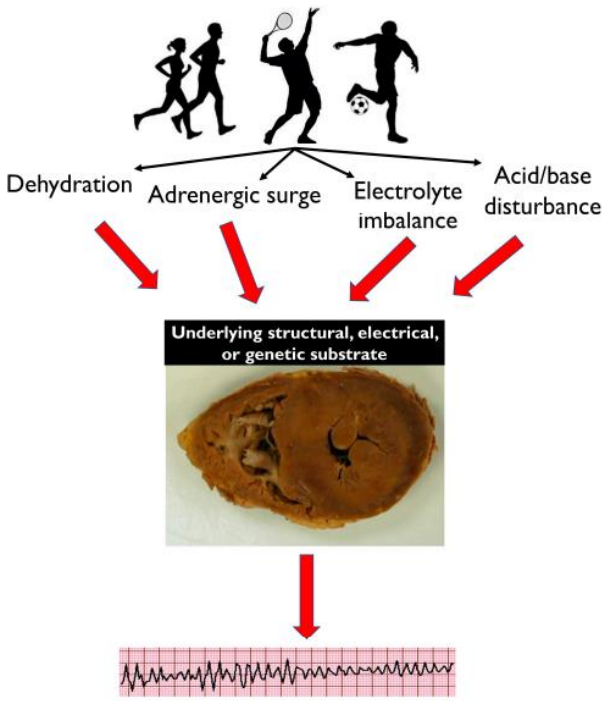

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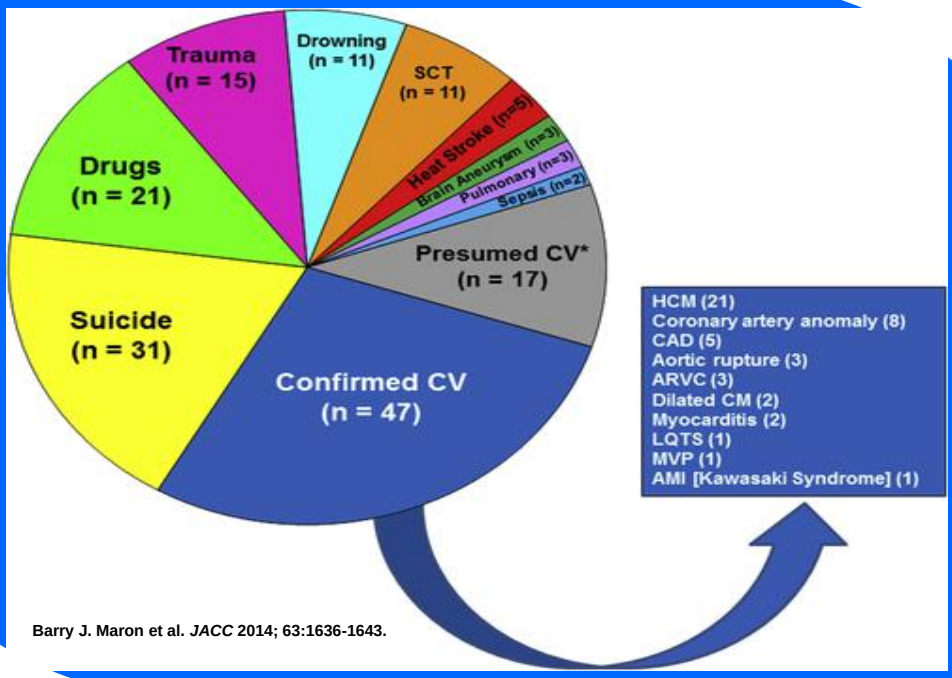

Barry J. Maron et al. *JACC* 2014; 63:1636-1643.

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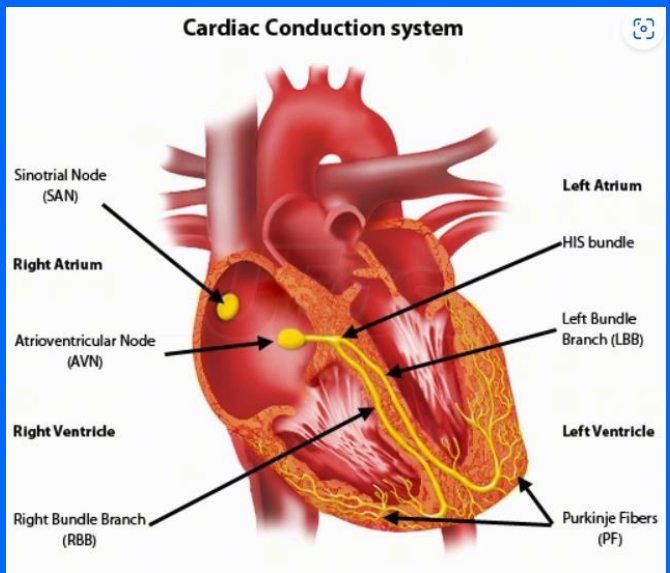

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Table 1. Main studies reporting on Incidence of SCD in athletes.

Authors—Year—Country Study Design	Case Identification	Denominator	SCD or SCA + SCD	Years Studied (n° of Years)	Population	Incidence	Age Range (Mean Age)	Number of Deaths
Besenius—2022—Luxembourg Prospective [17]	**Declaration by the general population (online questionnaires, public media, informed patients followed by the national cardiology institute and cardiac re-education centres, direct witnesses, and other publicly available information)**	**Cases of SrSCD on national territory or outside Luxembourg suffered by a Luxembourgish resident or sports license holder**	**SCD + SCA (+ myocardial infarctions and acute coronary syndromes)**	**2015–2019 (5)**	**Physically active population (competitive and non-competitive)**	**2.6 cases/year/100,000 physically active inhabitants**	**17–80 (49.7)**	**43 (17 fatal)**
Corrado—2003—Italy Prospective [18]	Mandatory death reporting	Registered Italian athletes	SCD	1979–1999 (20)	Athletes and young people	1:47,600 athlete 1:142,900 young people	12–35 (23)	55
Drezner—2005—USA Retrospective	Survey answered by 244/326 Div. I NCAA institutions	Number of athletes at surveyed schools	SCD		College athletes	1:67,000		5
Drezner—2009—USA Cross-sectional survey [19]	1710 high schools with AEDs surveyed for SCA or SCD	Number of student athletes reported by schools	SCA + SCD	2006–2007 (within 6 months of survey)	High school athletes	1:23,000 SCA + SCD 1:46,000 SCD	14–17 (16)	14
Drezner—2014—USA Retrospective	Media reports	NFHS	SCA + SCD	2003–2013 (10)	High school athletes	1:153,846 SCD 1:71,428 SCA 1:21,277 male basketball	14–18	6 SCD 7 SCA
Harmon—2011—USA Retrospective [20]	Parent Heat Watch database, NCAA Resolutions list, insurance claims	Participation data from NCAA	SCD	2004–2008 (4)	College athletes	1:43,770	18–26 (20)	37
Harmon—2014—USA Retrospective	Media reports	NFHS	SCA + SCD	2007–2013 (5)	High school athletes	1:63,988 SCA 1:41,662 male 1:33,815 male basketball	14–18	74 SCD 35 SCA
Holst—2010—Denmark Retrospective	**Review of death certificates, then autopsies if available**	**Denmark population statistics**	**SCD**	**2000–2006 (7)**	**Athletes and young people**	**1:82,645 SrSCD 1:26,595 general population**	**12–35 (26)**	**15 SrSCD 470 SCD**
Maron—1996—USA Retrospective	US Registry for Sudden Death in Athletes	"Unavoidable selection bias and certainly significantly underestimated"	SCD	1985–1995 (10)	Athletes		12–40 (17)	134

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Table 1. *Cont.*

Authors—Year—Country Study Design	Case Identification	Denominator	SCD or SCA + SCD	Years Studied (n° of Years)	Population	Incidence	Age Range (Mean Age)	Number of Deaths
Maron—1998—USA Retrospective	Insurance claims	Minnesota State High School League	SCD	1985–1997 (12)	High school athlete	1:217,000 overall 1:129,000 male 0 for female	16–17 (16.5)	3
Maron—2003—USA Retrospective	US Registry for Sudden Death in Athletes	Not possible b/c of selection bias	SCD	1985–2000 (25)	Athletes		9–40 (17)	286
Maron—2009—USA Retrospective [21]	US Registry for Sudden Death in Athletes	Not described (estimated 10.7 million athletes < 39 participating in sports during 2000-2006)	SCA + SCD	1980–2006 (27)	Athletes	1:163,934	8–39 (18)	690
Maron—2013—USA Retrospective	US Registry of Sudden Death in Athletes	Minnesota State High School League	SCD	1986–2011 (26)	High school athletes	1:150,000	12–18 (16)	13
Maron—2014—USA Retrospective [22]	US Registry for Sudden Death in Athletes and NCAA resolutions list for cardiac cases	Participation data from NCAA	SCD	2002–2011 (9)	College athletes	1:62,000 presumed 1:83,000 confirmed	17–26 (20)	64
Peterson—2021—USA Prospective [23]	National Center for Catastrophic Sports Injury Research in collaboration with national sports organizations	Participation data from National Federation of State High School Associations and NCAA	SCD + SCA	2014–2018 (4)	Competitive athletes	High school level: 1:65,872 athlete years NCAA level: 1:50,768 athlete-year	11–29 (16.7)	331 SCA + SCD 173 SCD
Roberts—2013—USA Retrospective [24]	MSHSL records	Participation data from MSHSL records	SCD	1993–2012 (19)	High school athletes	0.24 per 100,000 athlete years	12–19 "most aged 15 to 18")	4
Steinvil—2011—Israel Retrospective	Retrospective review (2 Israeli newspapers by 2 media researchers)	45,000 registered competitive athletes in 2009, extrapolating the growth of the Israeli population for those aged 10–40 born after 1985 based on a figure allowed for presumed doubling of the sport-participating population	SCD	1985–2009 (24)	Athletes	1st 1:39,370 2nd 1:37,593	12–44 (24)	24
Toresdahl—2014—USA Prospective [25]	2149 schools with cases of SCA + SCD occurred on school campus	Number of student athletes reported by schools	SCA + SCD	2009–2011 (2)	High school athletes	1:87,719 SCA + SCD 1:57,000 male SCA + SCD	14–18	18 SCA + SCD 2 SCD

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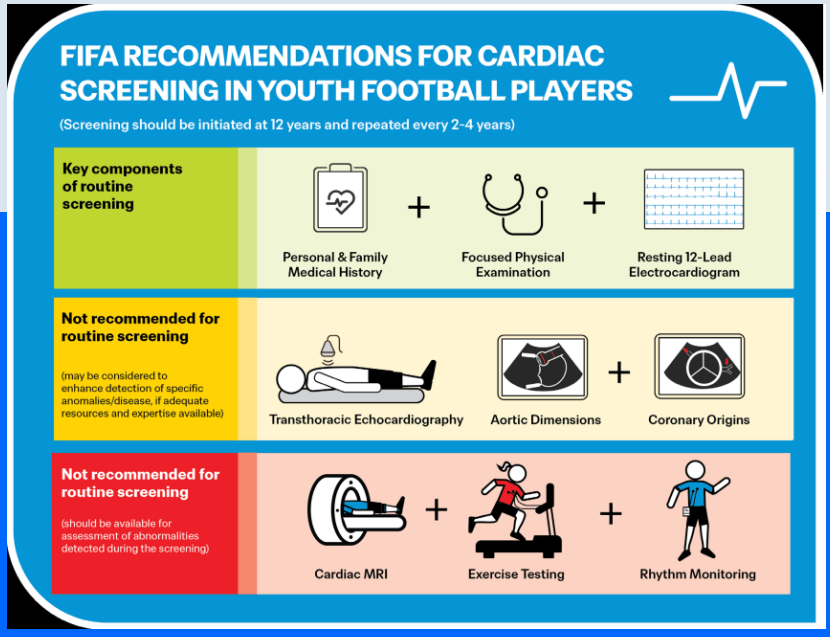

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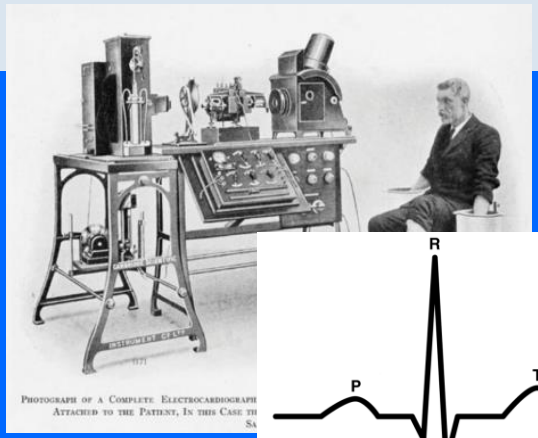
It all starts with the EKG (or ECG)



- 1903 Nobel Prize – Dutch physician (Einthoven).
- Recognized the EKG features (P wave, QRS complex, T wave)
- Mathematicians in the 1800s only used letters from the second half of the alphabet (N has other meanings, O is typically used for origin of coordinates…P is the next letter)

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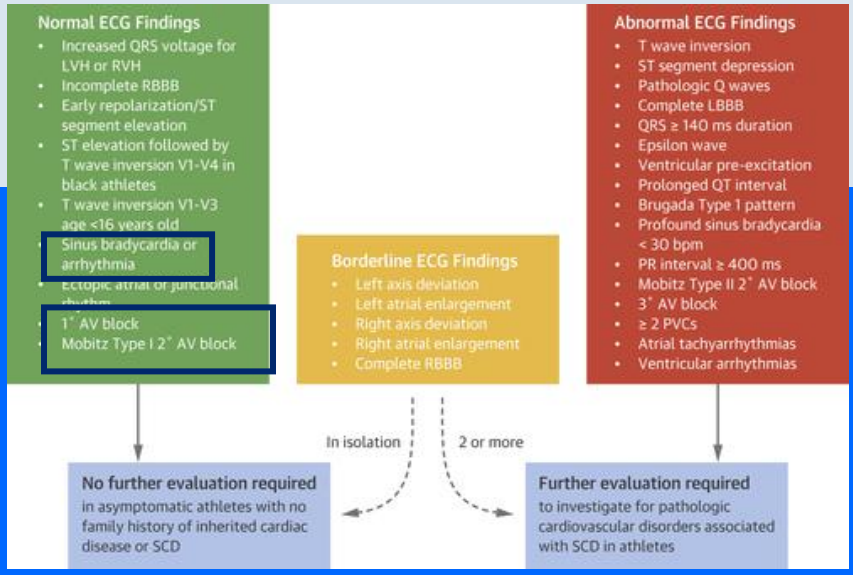

Sanjay Sharma et al. *JACC* 2017; 69:1057-1075.

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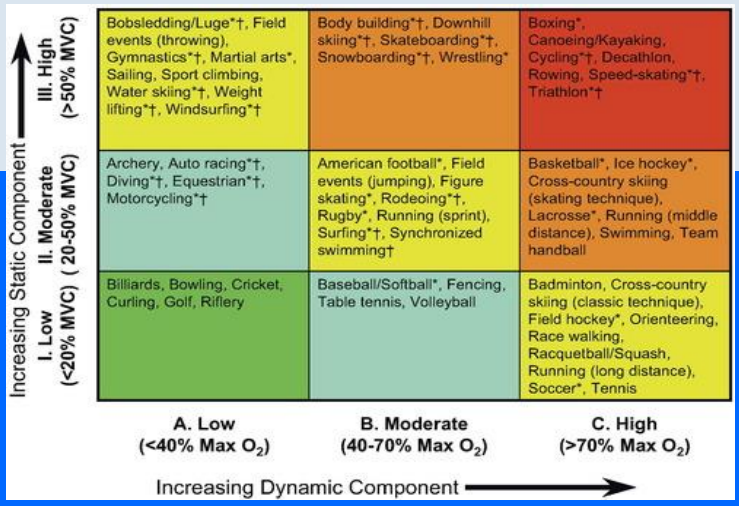

Jere H. Mitchell et al. *JACC* 2005; 45:1364-1367.

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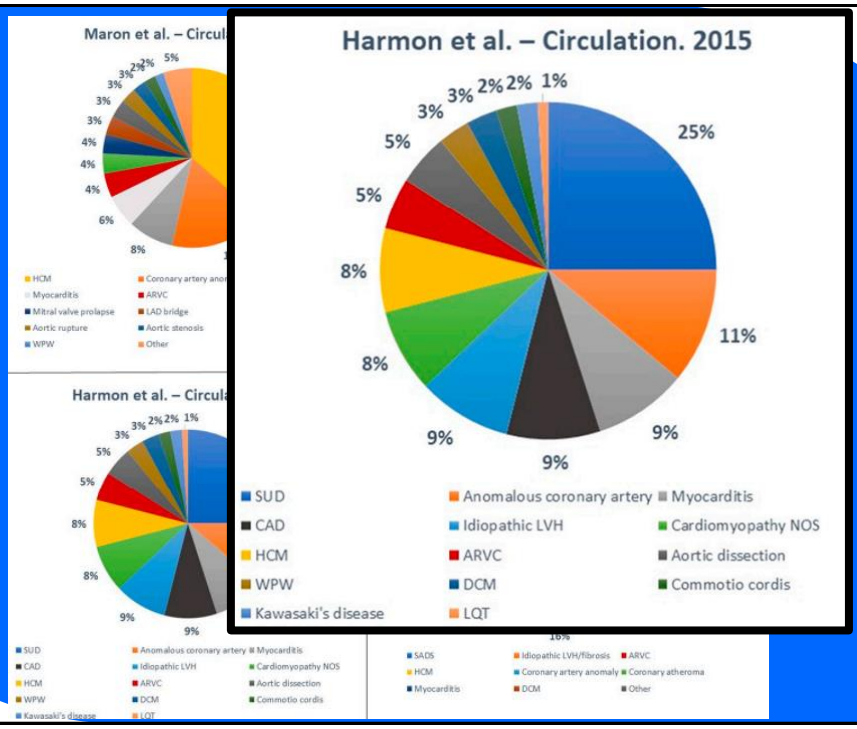

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There are many types of arrhythmias, we are going to focus on the most common and most concerning.

1. Atrial Fibrillation
2. Premature Ventricular Contractions
3. Premature Atrial Contractions

1. Ventricular tachycardias
2. Supraventricular tachycardia
3. AVNRT
4. WPW and AVRT

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17 year old female cross country runner reports feeling that her heart is "skipping beats" while exercising. She is under more stress recently at school and also started drinking energy drinks to stay awake in class.

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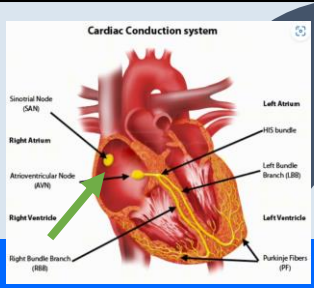
Premature Atrial Contractions



- Frequently observed in healthy population, benign arrhythmia
- My heart "skipped" a beat
- Abnormal P wave followed by normal QRS

- No further work-up considered typically unless becomes frequent or associated with symptoms
- May have some prognostic value in predicting people who will develop atrial fibrillation

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How to counsel athletes?

1. Common triggers:

- Anxiety
- Caffeine
- Low potassium
- Low magnesium
- sympathomimetics

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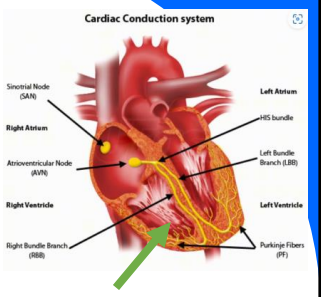
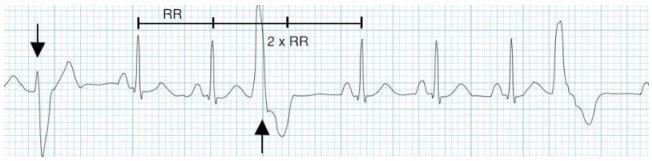
Premature Ventricular Complexes

- Extrasystolic single wide complex beats that originate from the ***ventricle***.
- Observed on up to 75% of healthy patients on Holter monitors
- More common in athletes
- Not usually associated with structural heart disease or increased risk of SCD.





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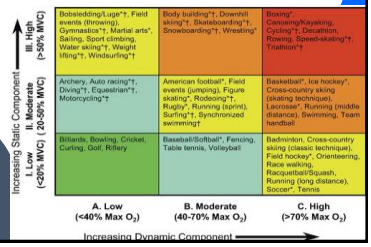
PVC Management

- Athletes without structural heart disease who have asymptomatic PVCs at rest or with exercise can participate in all events.
- If PVCs increase with exercise and cause symptoms, limit to IA sports.
- More concerning if WPW also present (or ischaemic heart disease in older individuals)



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Cardiac autonomic regulation following a 246-km mountain ultra-marathon: An observational study

Tsai, I-Hsun MD[a]; Kao, Wei-Fong MD, PhD[b]; How, Chorng-Kuang MD, PhD[c,d]; Li, Li-Hua PhD[e,f]; Lin, Yen-Kuang PhD[g]; Kung, Lu-Chih MD[h,i]; Chiu, Yu-Hui MD, PhD[b,h,i,*]; Chien, Ding-Kuo MD, MS[h,i]; Chang, Wen-Han MD, MHA, DrPH[h,i]

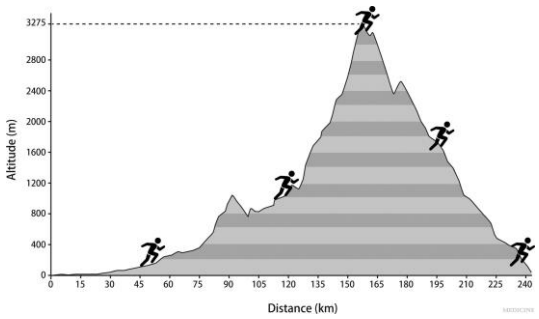
Author Information

Medicine 103(27):p e38756, July 05, 2024. | *DOI:* 10.1097/MD.0000000000038756

33.3% of runners had PVC signals after MUM, non had nonsustained ventricular tachycardia.

Found an association between running speed and PVC frequency.

Unclear if this makes them more prone to arrhythmia



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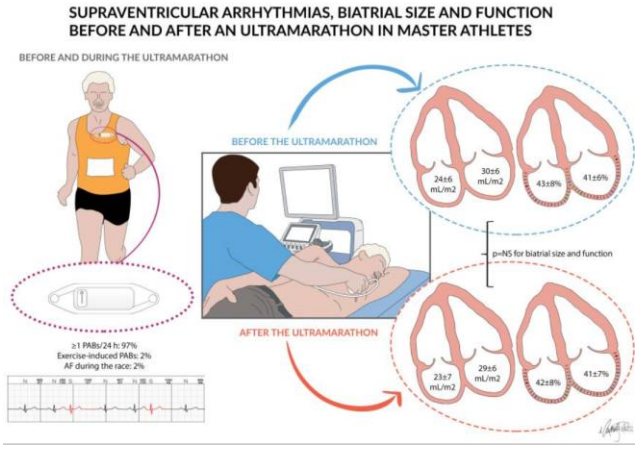
J Clin Med. 2022 Jan 20;11(3):528. doi: 10.3390/jcm11030528

The Acute Effects of an Ultramarathon on Atrial Function and Supraventricular Arrhythmias in Master Athletes

Luna Cavigli [1], Alessandro Zorzi [2], Veronica Spadotto [3], Giulia Elena Mandoli [1], Andrea Melani [1], Chiara Fusi [1], Antonello D'Andrea [4], Marta Focardi [1], Serafina Valente [1], Matteo Cameli [1], Marco Bonifazi [5], Flavio D'Ascenzi [1,*]



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56 year old master athlete presents to sports medicine clinic for evaluation of "palpitations" that seem to get worse when he exercises.

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Atrial Fibrillation (Afib)

- Can be triggered by physical exertion
- 0.3% in athletes (about 25% prevalence in individuals >40 yo
- Disorganized impulses from multiple electrical foci that overwhelm the normal conduction system
- Heart rate becomes rapid and irregularly irregular
- Symptoms: palpitations to syncope
- Athletes thought to develop this at a younger age because of increased cardiac output and, possibly, inflammation.

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Other causes of Afib

- Congenital heart disease (septal defect)
- Hemochromatosis (iron overload)
- Hypothermia
- Alcohol
- Caffeine
- Myocarditis

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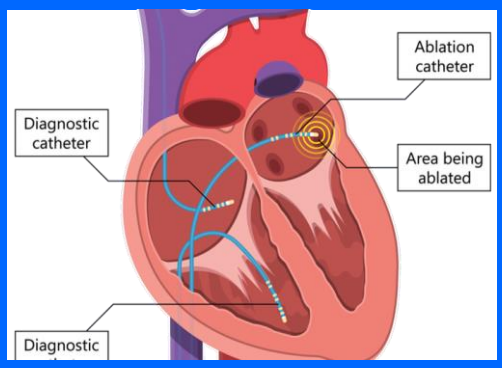
Management of Afib

- Athletes with afib but ***no evidence of structural heart*** disease can compete without restrictions if they are able to maintain a normal dynamic range of their heart rate with exercise.
- Can consider radiofrequency ablation to restore sinus rhythm (Sports participation 4-6 weeks after ablation).
- Blood thinner considerations



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21 year old lacrosse player presents to the athletic training room reporting her heart racing abnormally during exercise. She denies any presyncope during exercise.

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	Ventricular Tachycardias (VT)	Supraventricular Tachycardias (SVT)
Origin	Ventricles	Atria or AV node
Heart Rate	Typically >100 bpm	Typically >100 bpm
ECG Characteristics	Wide QRS complexes	Narrow QRS complexes
Symptoms	Palpitations, dizziness, syncope	Palpitations, dizziness, shortness of breath
Potential Causes	Heart disease, electrolyte imbalances	Stress, caffeine, alcohol, heart disease
Treatment Options	Antiarrhythmic drugs, cardioversion, ablation	Vagal maneuvers, medications, ablation
Risk Level	Higher risk of serious complications	Generally less severe but can be problematic

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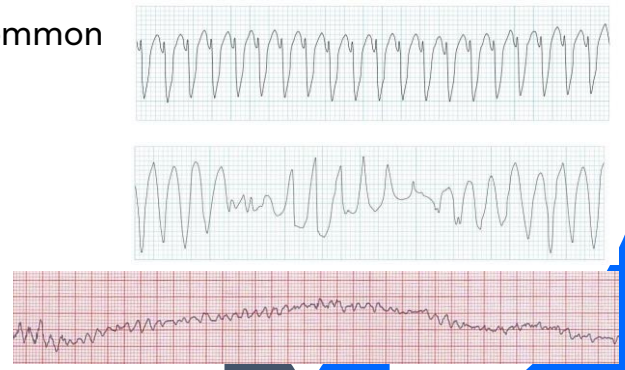
Ventricular tachycardias

- Broad complex tachycardia originating from ventricles
- Monomorphic VT is most common
- Other versions:
  - Torsades De Pointes
  - Ventricular Fibrillation



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Management of VT

- Stable or ***Unstable → ACLS protocol***
- Nonsustained
  - 3 or more consecutive ventricular beats >120 bpm lasting less than 30 seconds.
- Sustained
  - >30 seconds
- Complete a thorough evaluation – echocardiogram, cardiac MRI.

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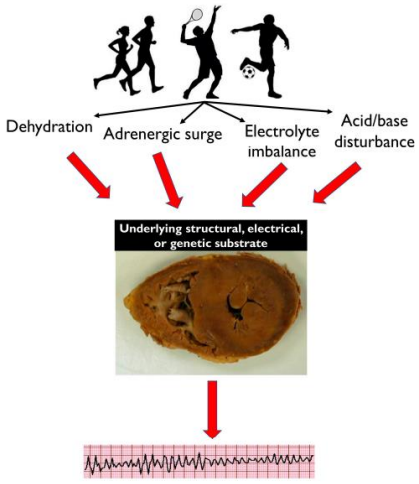
Return to sport after VT

- Nonsustained VT – if negative work-up, currently no association with increased risk of SCD.
  - If exercise testing does not show worsening of VT with exercise, can participate in all competitive sports
- Sustained VT – NEED to find the source, could be life-threatening.
  - Structurally normal heart
    - If candidate for ablation – can return after 4 weeks of no recurrence
    - If ablation not an option – medication therapy is an option
      - More conservative return to play as the ***catecholamine surge with sports can counter the effects of the drug*** and VT can reemerge.
      - No sports for at least 2-3 months after the last VT episode and should get stress ECG before returning to play



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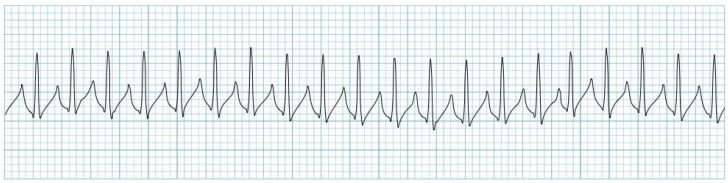
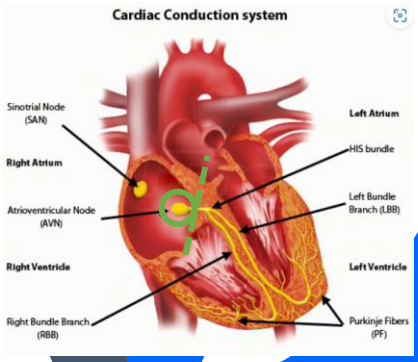
Supraventricular Tachycardia

- Any arrhythmia originating above the level of the bundle of His
- AVNRT (AV nodal re-entrant tachycardia) are most common in young, otherwise healthy individuals
- Regular tachycardia 140-280





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AVNRT Management

- Prior to treatment – athletes who have symptoms should not participate in competitive sports until they have been treated
- Refer to cardiology for consideration of ablation
- After ablation if no recurrence after 4 weeks can return to sport.
- If ablation deferred/declined AND episodes are brief and sporadic AND without symptoms they can participate in sport with regular follow-up.

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14 year old track and field player reports having had an episode of passing out while running and also frequently gets lightheadedness and dizziness with longer distances.

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Wolff-Parkinson-White syndrome

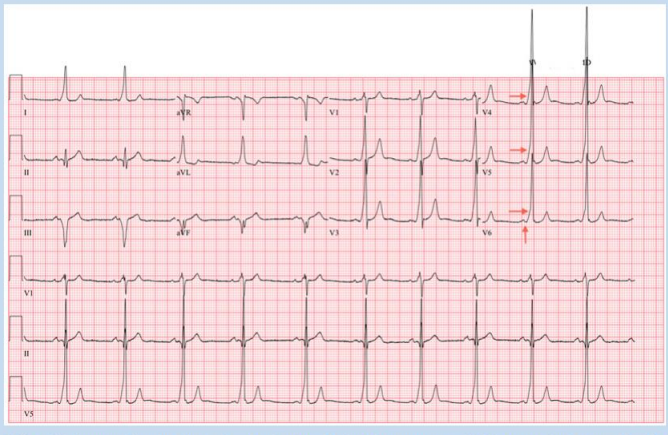

Figure 2. ECG at initial preparticipation physical evaluation (preablation) demonstrates a WPW pattern. Red arrows identify the characteristic delta wave and short PR interval. ECG, electrocardiogram; WPW, Wolff-Parkinson-White.

Figure 1. Characteristic ECG findings in WPW. Note the presence of a short PR interval (<120 ms) and delta wave (slurred upstroke of the QRS complex). ECG, electrocardiogram.

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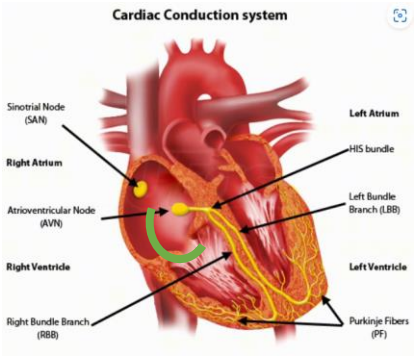
Wolff-Parkinson-White syndrome

- "Pre-excitation" syndrome
- Accessory pathway bypasses the gatekeeper
- Congenital – happens during fetal development



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'Pattern' vs 'Syndrome'

- WPW pattern
  - Abnormal EKG but no symptomatic arrhythmias
  - 10 to 100 times more common than WPW syndrome (both are present in less than 1% of general population).
  - 0.13-0.23% of general population. 0.55% among first degree relatives of persons with the WPW pattern
  - ***Can disappear and reappear on EKGs, not consistently there***
- WPW Syndrome
  - Abnormal EKG AND symptomatic arrhythmias (AVRT)
  - 1% of those with WPW pattern have WPW syndrome

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Symptoms of WPW syndrome

- Palpitations
- Lightheadedness/dizziness
- Syncope or presyncope
- Chest pain
- Sudden cardiac arrest

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Management of WPW

- Symptomatic patients (those with WPW syndrome) should be offered ablation
- Success rate of >95% with low risk of complications
- Return to sport after ablation:
  - If remain asymptomatic, normal AV conduction, delta wave gone on ECG after ablation can return to full sports after 4-6 weeks.

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Screening questions we as our athletes at PPE

- Any chest pain or chest pressure with exercise?
- Have you ever passed out during exercise?
- Do you ever feel your heart is skipping a beat or doing flips in your chest when you exercise?

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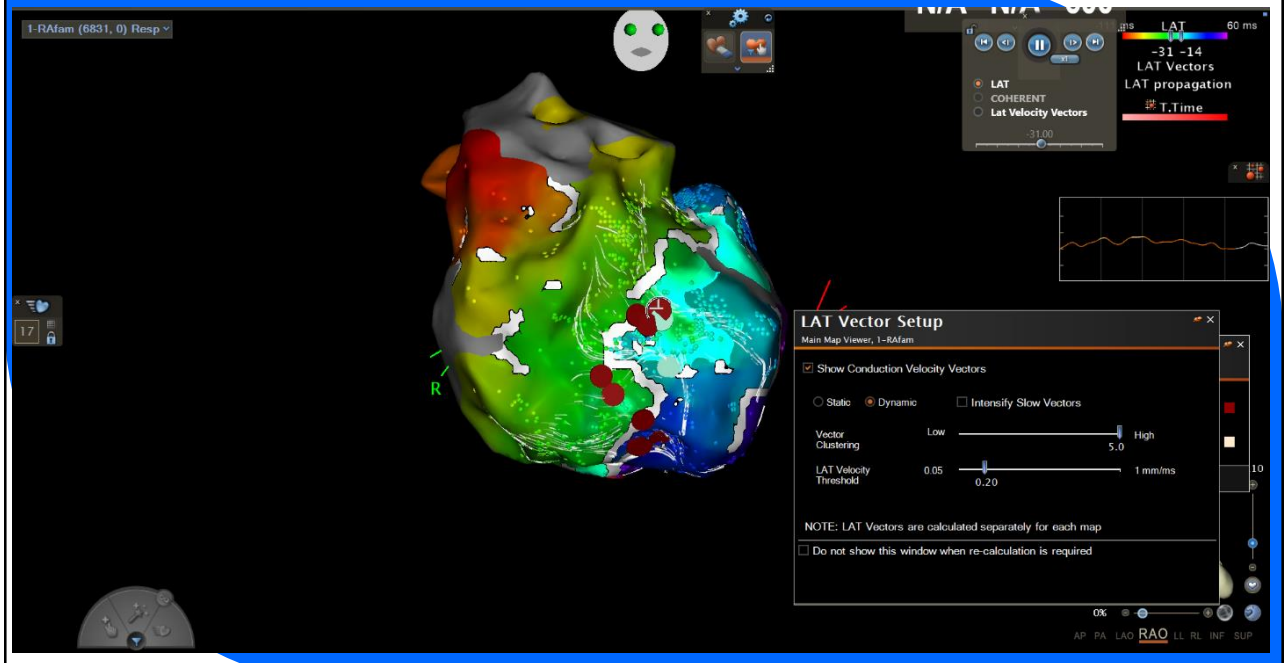

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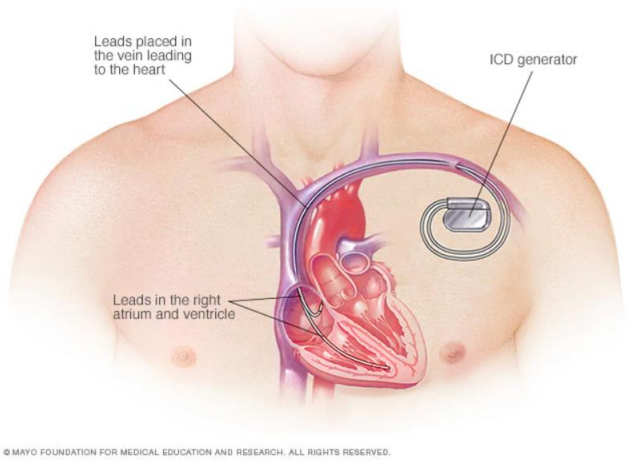
A word about ICDs…

- Shared decision-making process
  - Depends on reason for ICD, type of sport being played
  - Higher risk of arrhythmia and damage to ICD.
  - If playing, may need to undergo formal exercise testing to help with programming of ICD device



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Closing thoughts

- The benign arrhythmias are thankfully more common than worrisome arrhythmias in athletes
- Athletes place increased demand on the heart, increase susceptibility to lethal arrhythmia
- The pre-participation screening process is important to detect those who may be at increased risk
- Other things are more likely to harm our athletes than cardiac arrhythmias
- Know your athletes, have an EAP and practice it to prevent a catastrophic event.

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