Sports Cardiology Focus: Cardiac Conditions in Athletes

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Chair-Elect American College of Cardiology Sports & Exercise Cardiology Council

Emergency Care in Sport 2023
February 19, 2023

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Disclosures

- No financial conflicts
- Athletic Affiliations:


- Research Support:

  NIH (NHLBI) , Atlanta Track Club

- League Affiliations:

Outline / Objectives

1. Risk of Sudden Cardiac Death in Athletes
2. Cardiac Etiologies Associated with Sudden Cardiac Death in Athletes
3. The Changing Landscape of Sports Cardiology…We've Only Just Begun!

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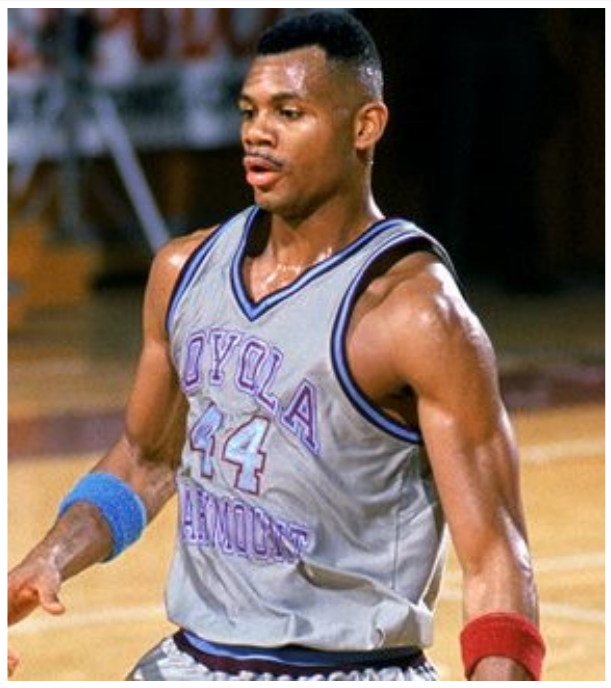


1990

2020

2023

2021

Incidence of SCA/D in Men Versus Women

Author	Year	Age of cohort	# Male SCA/D	Person-Years	Male Incidence	# Female SCA/D	# Female Person-years	Female Incidence
Corrado	2003	12-35	46	1,904,490	1:41,402	5	464,100	1:92,820
Toresdahl*	2014	high school	16	924,000	1:57,750	2	652,828	1:326,414
Harmon	2015	college	64	2,418,563	1:37,790	15	1,823,899	1: 121,593
Harmon	2016	high school	92	4,124,525	1:44,832	12	2,850,115	1:237,510
Peterson*	2020	high school	176	7,732,032	1:43,932	28	5,706,008	1: 203,786
		college	32	1,116,992	1:34,906	7	862,946	1:123,278
Total			**426**	**18,220,602**	**1:42,771**	**69**	**12,359,896**	**1:179,129**

*Included both SCA and SCD

- Males are at 4x the risk of Females

- 86% of deaths occurred in Males

Table courtesy of Matt Martinez

Incidence of SCD by Self-Identified Race

Study	Year Published	Years Studied	Age	Black	White	Relative Risk
Maron	2014	2002 - 2011	17-26	1:26,000	1:143,000	5.50
Harmon*	2015	2003 - 2013	18-26	1:21,000	1:68,000	3.23
Peterson	2020	2014 – 2018	College	1:18,000 (males)	1:39,000 (males)	2.10

*Rigorous case ID (3 mechanisms)

Table courtesy of Matt Martinez

Incidence, Cause, and Comparative Frequency of Sudden Cardiac Death in National Collegiate Athletic Association Athletes

A Decade in Review

Kimberly G. Harmon, MD; Irfan M. Asif, MD; Joseph J. Maleszewski, MD; David S. Owens, MD, MS; Jordan M. Prutkin, MD, MHS; Jack C. Salerno, MD; Monica L. Zigman, MPH; Rachel Ellenbogen, MS; Ashwin L. Rao, MD; Michael J. Ackerman, MD, PhD; Jonathan A. Drezner, MD

Circulation

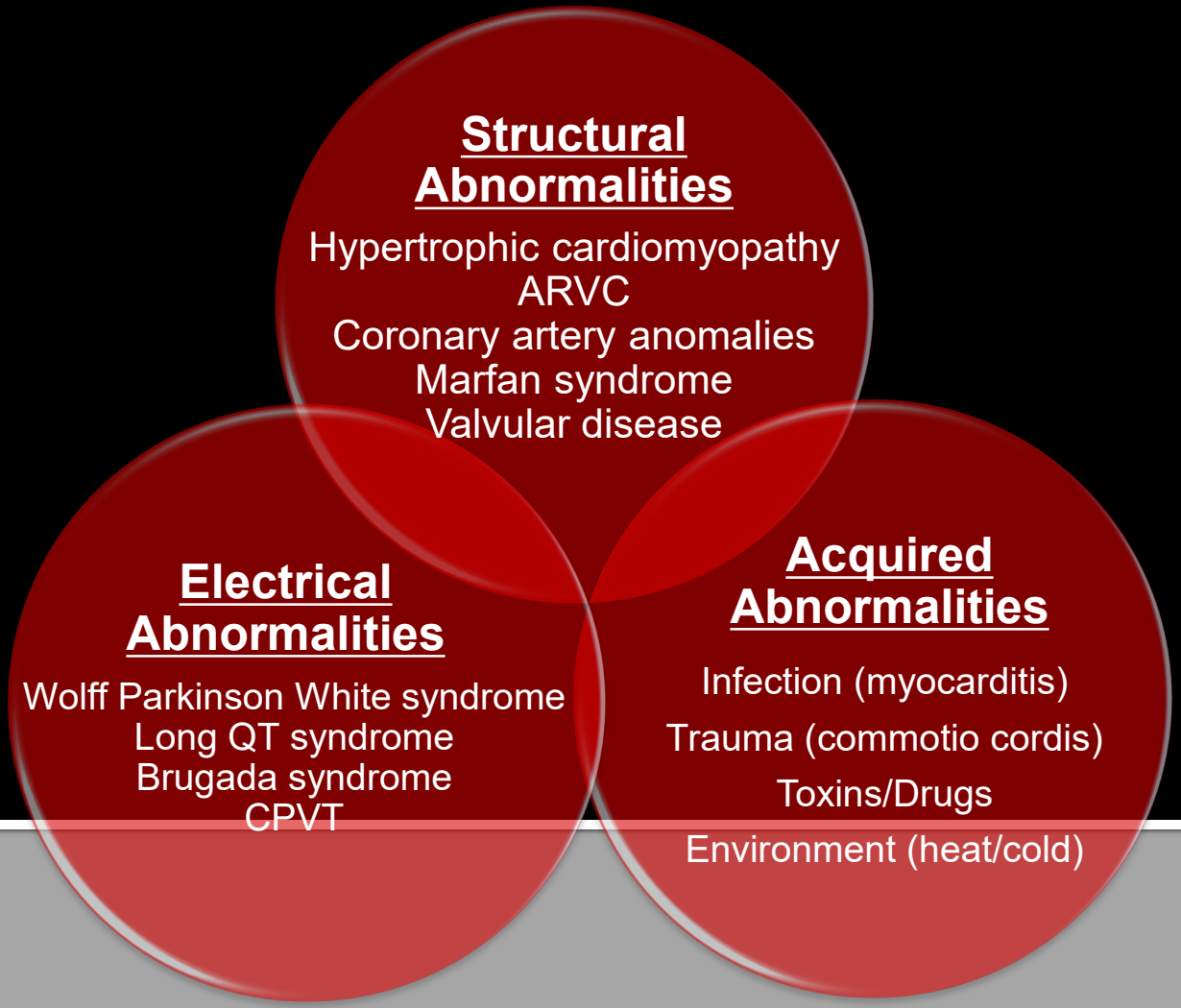
Table 3. Incidence of Sudden Cardiac Death in NCAA Athletes

Characteristic	Athlete-Years	SCD	Incidence per Athlete-Year	IRR
Overall	4 242 519	79	1 in 53 703	–
Sex				
Male	2 418 563	64	1 in 37 790	3.22
Female	1 823 899	15	1 in 121 593	1.00
Division				
Division 1	1 663 441	38	1 in 43 775	1.98
Division 2	930 434	22	1 in 42 292	2.05
Division 3	1 648 128	19	1 in 86 744	1.00
Race				
White	3 075 942	45	1 in 68 354	1.00
Black	644 715	30	1 in 21 491	3.18
Hispanic	168 763	3	1 in 56 254	1.22
Other	353 042	1	1 in 353 042	0.19

- Database of all NCAA deaths 2003-2013
- Most common medical cause of death was CV
- Males higher risk vs. females
- Black athletes at higher risk vs. White athletes (1:21,491 AY vs. 1:68,354 AY)
- Men's basketball at highest risk (1:8,978 AY)

Harmon KH. *Circulation* 2015.

Cardiac Etiologies (<35 years-old)



Adapted from Chandra N. *J Am Coll Cardiol* 2013.

American Heart Association®
Learn and Live

Medical history*

Personal history

1. Chest pain/discomfort/tightness/pressure related to exertion
2. Unexplained syncope/near-syncope†
3. Excessive and unexplained dyspnea/fatigue or palpitations, associated with exercise
4. Prior recognition of a heart murmur
5. Elevated systemic blood pressure
6. Prior restriction from participation in sports
7. Prior testing for the heart, ordered by a physician

Family history

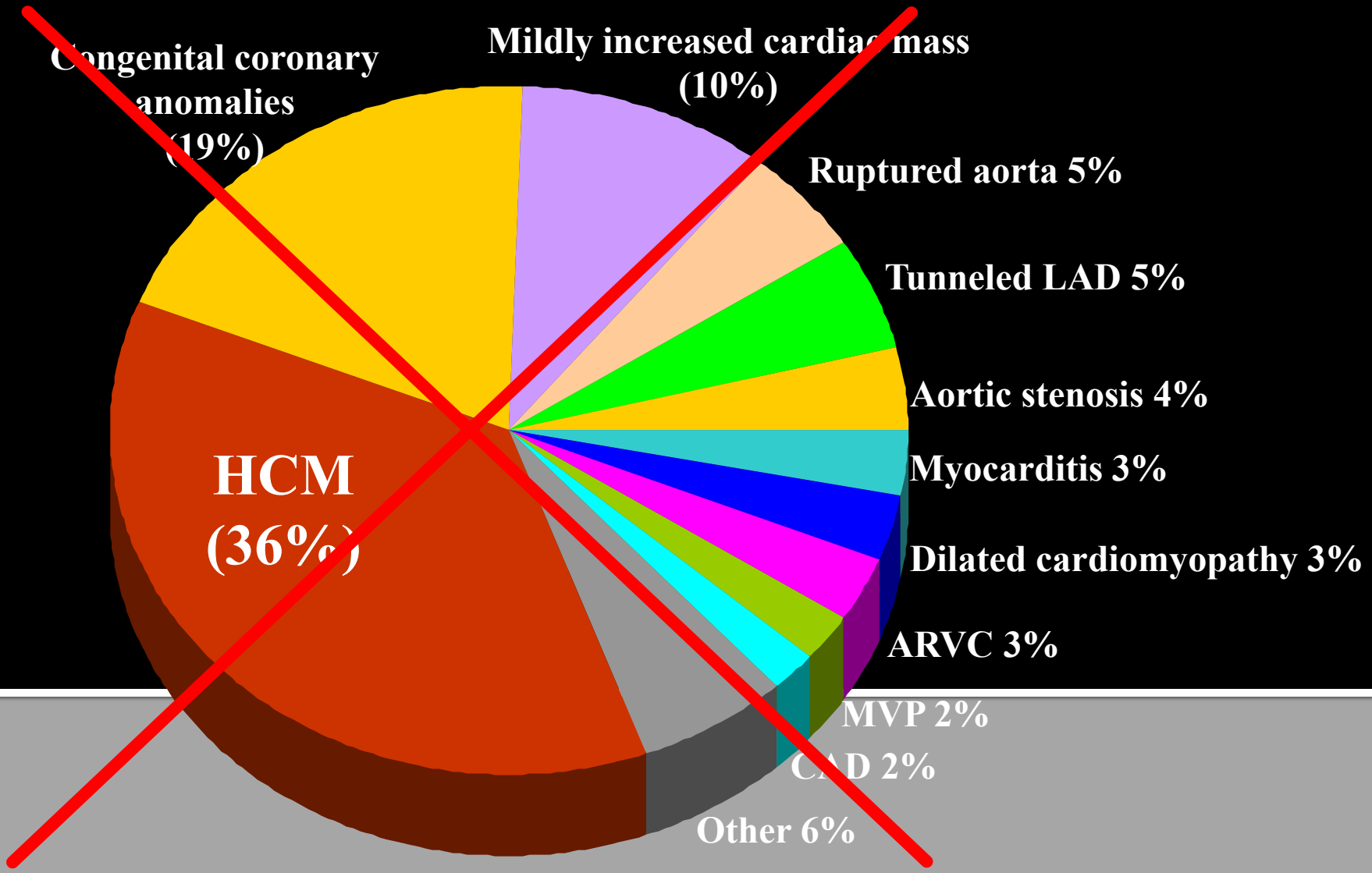
8. Premature death (sudden and unexpected, or otherwise) before 50 y of age attributable to heart disease in ≥1 relative
9. Disability from heart disease in close relative <50 y of age
10. Hypertrophic or dilated cardiomyopathy, long-QT syndrome, or other ion channelopathies, Marfan syndrome, or clinically significant arrhythmias; specific knowledge of genetic cardiac conditions in family members

Physical examination

11. Heart murmur‡
12. Femoral pulses to exclude aortic coarctation
13. Physical stigmata of Marfan syndrome
14. Brachial artery blood pressure (sitting position)§

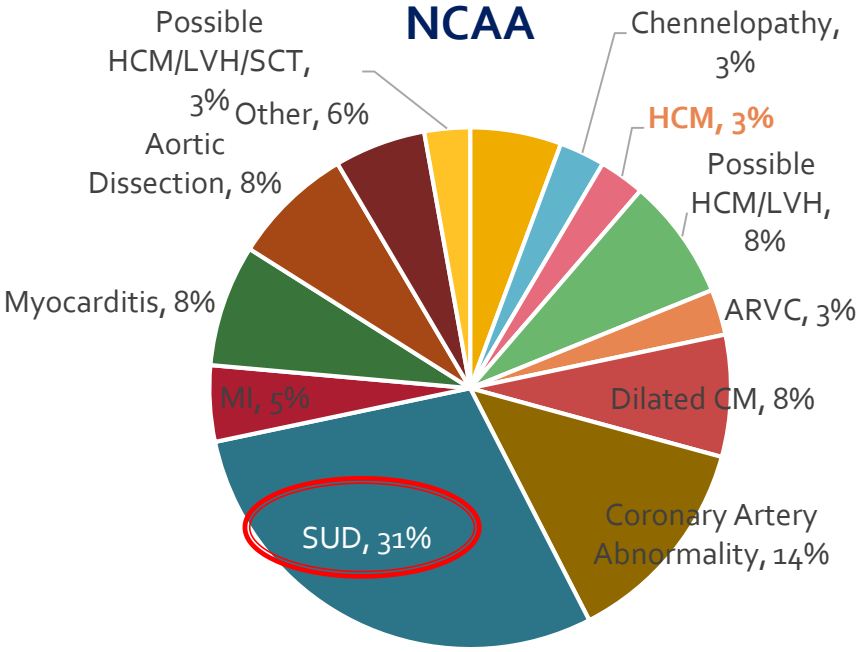
Maron BJ. *Circulation* 2014.

The 'Old' Breakdown…

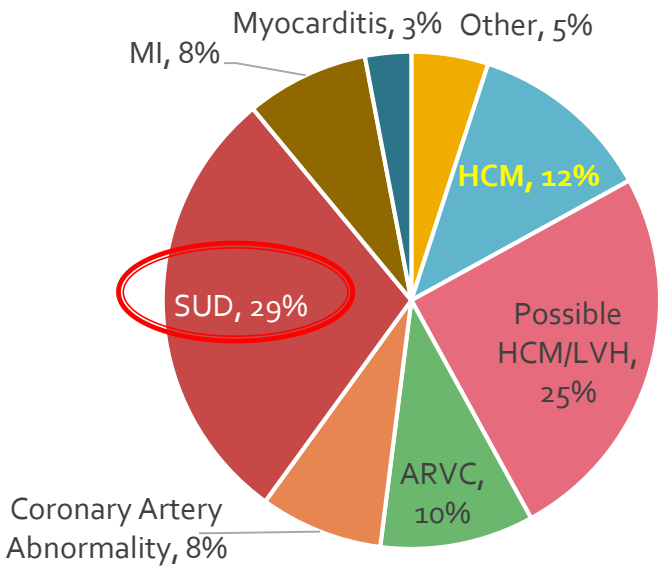


Maron BJ. *Circulation* 1996.

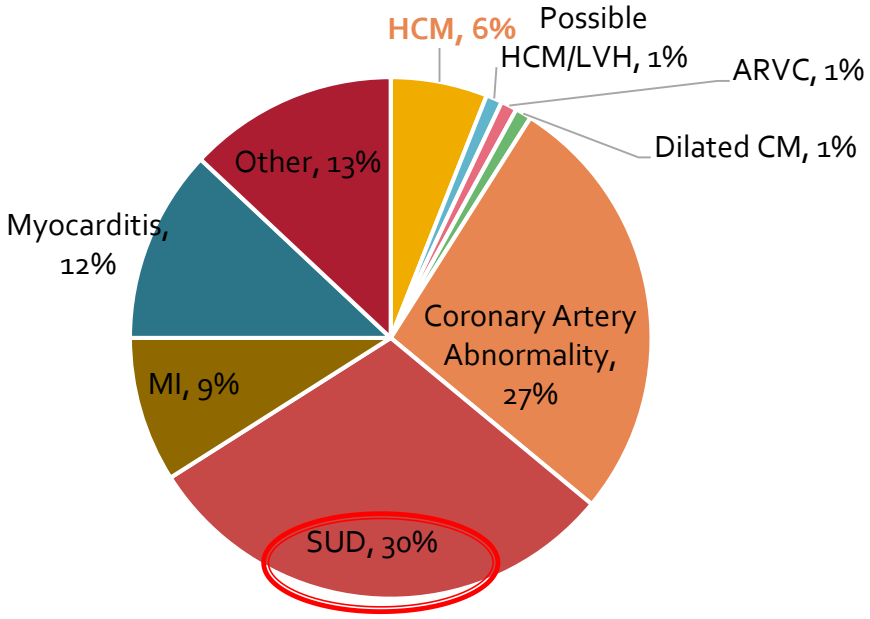
NCAA



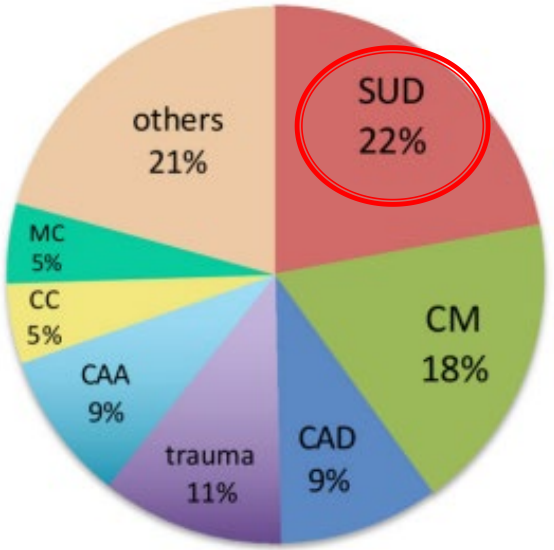
United Kingdom



US Military



FIFA, 2014-2018



Pie charts courtesy of Matt Martinez

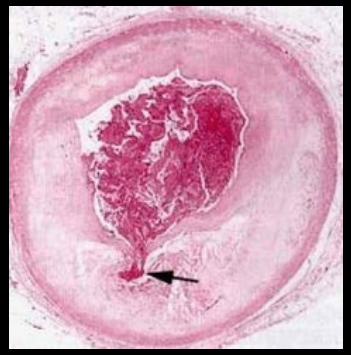
Eckart RE. *Ann Intern Med* 2004.
Harmon KG. *Circ Arrhythm Electrophysiol* 2014.
De Noronha SV. *Heart* 2009.

Etiology- Age >35

- **Acute Plaque Disruption**

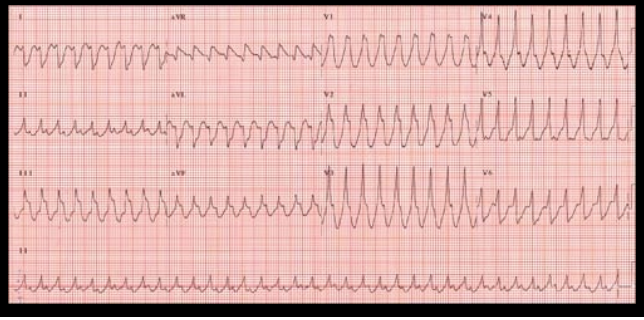
  -Possible mechanisms include increased wall stress,

  exercise-induced coronary artery spasm



- **Ventricular Arrhythmia**

  -At the site of scar or peri-infarction ischemic tissue

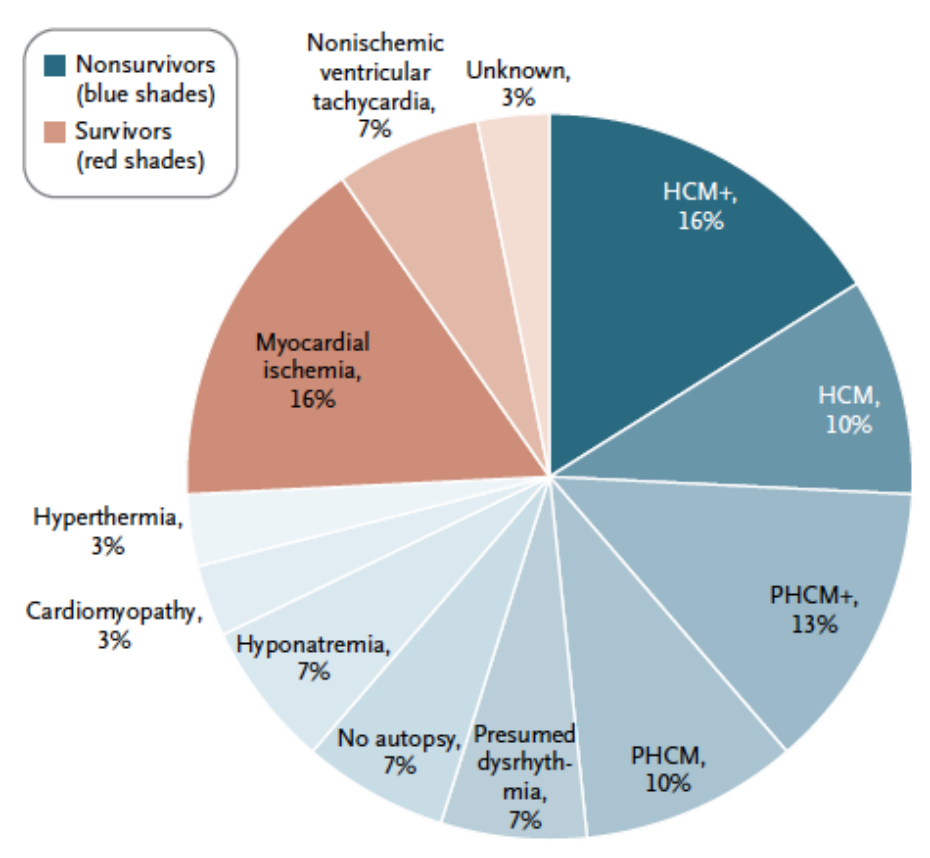


Thompson PD. *Circulation* 2007.

Cardiac Arrest during Long-Distance Running Races

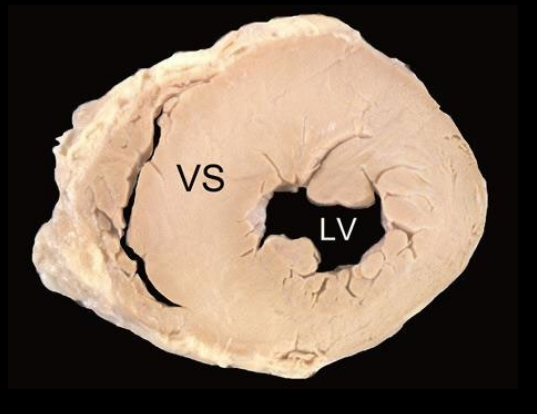
Jonathan H. Kim, M.D., Rajeev Malhotra, M.D., George Chiampas, D.O., Pierre D'Hemecourt, M.D., Chris Troyanos, A.T.C., John Cianca, M.D., Rex N. Smith, M.D., Thomas J. Wang, M.D., William O. Roberts, M.D., Paul D. Thompson, M.D., and Aaron L. Baggish, M.D., for the Race Associated Cardiac Arrest Event Registry (RACER) Study Group

The NEW ENGLAND JOURNAL of MEDICINE

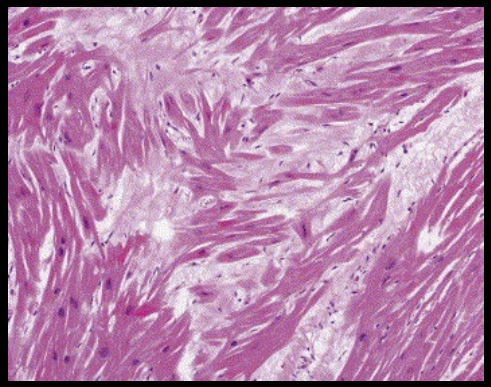


Kim JH et al. *N Engl J Med* 2012;366:132-42

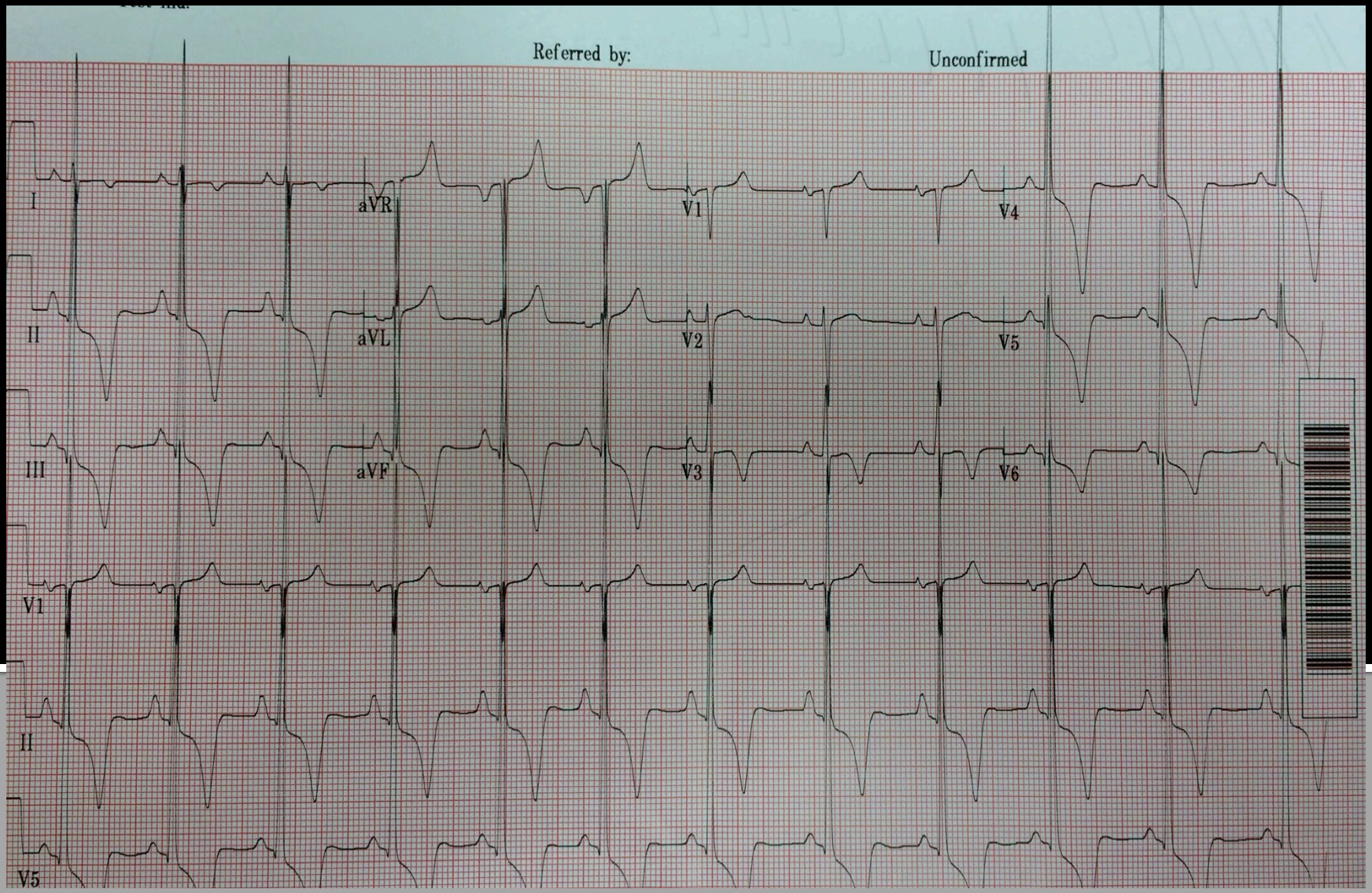
Hypertrophic Cardiomyopathy



- Autosomal dominant with variable penetrance
- LVH in absence of of elevated loading conditions, and with myocardial disarray on pathology
- Sudden death often first clinical manifestation of the disease
- Prevalence 1:500 (0.2%)
- Overall risk of SCD ~ 1% per year

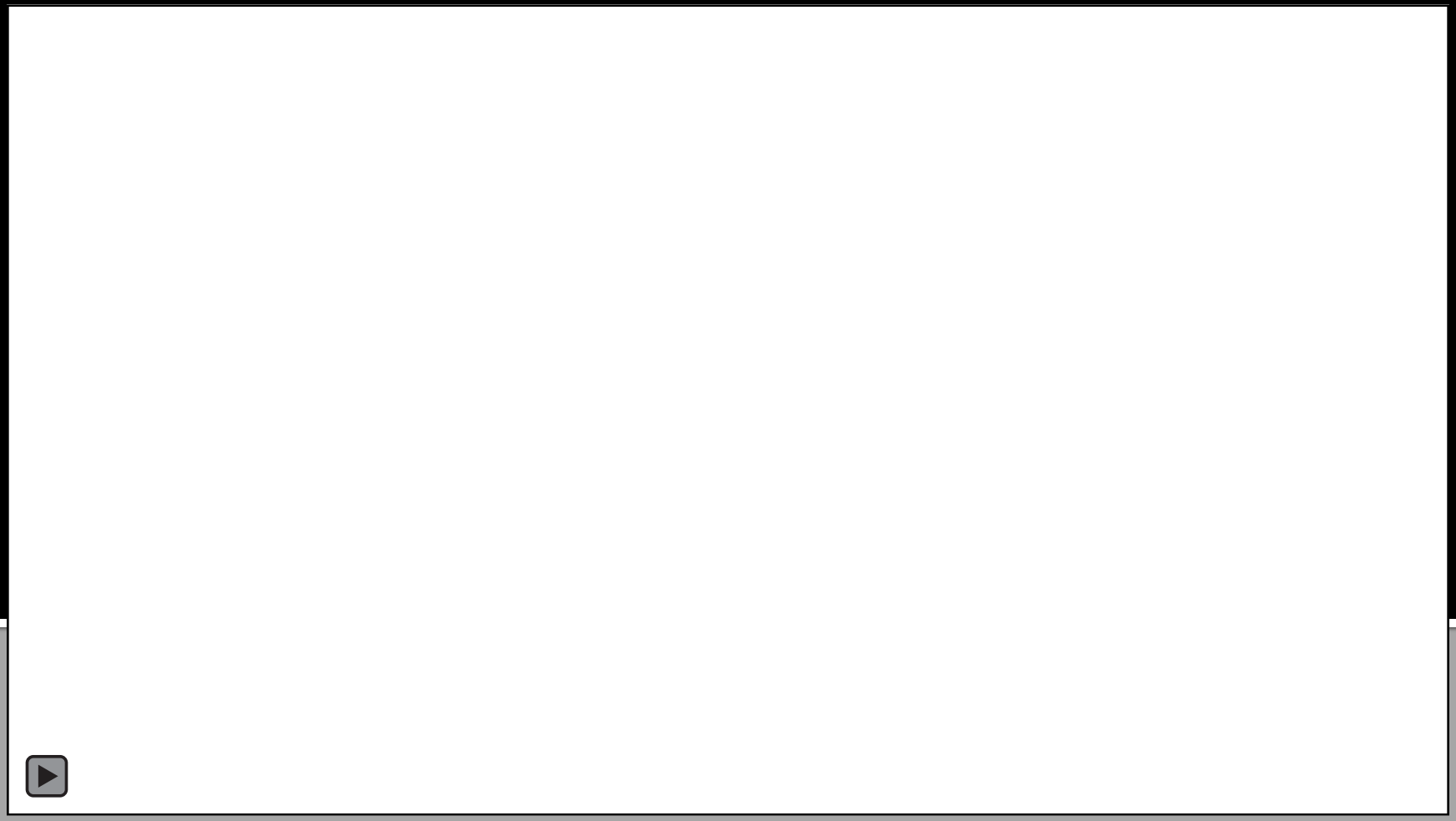


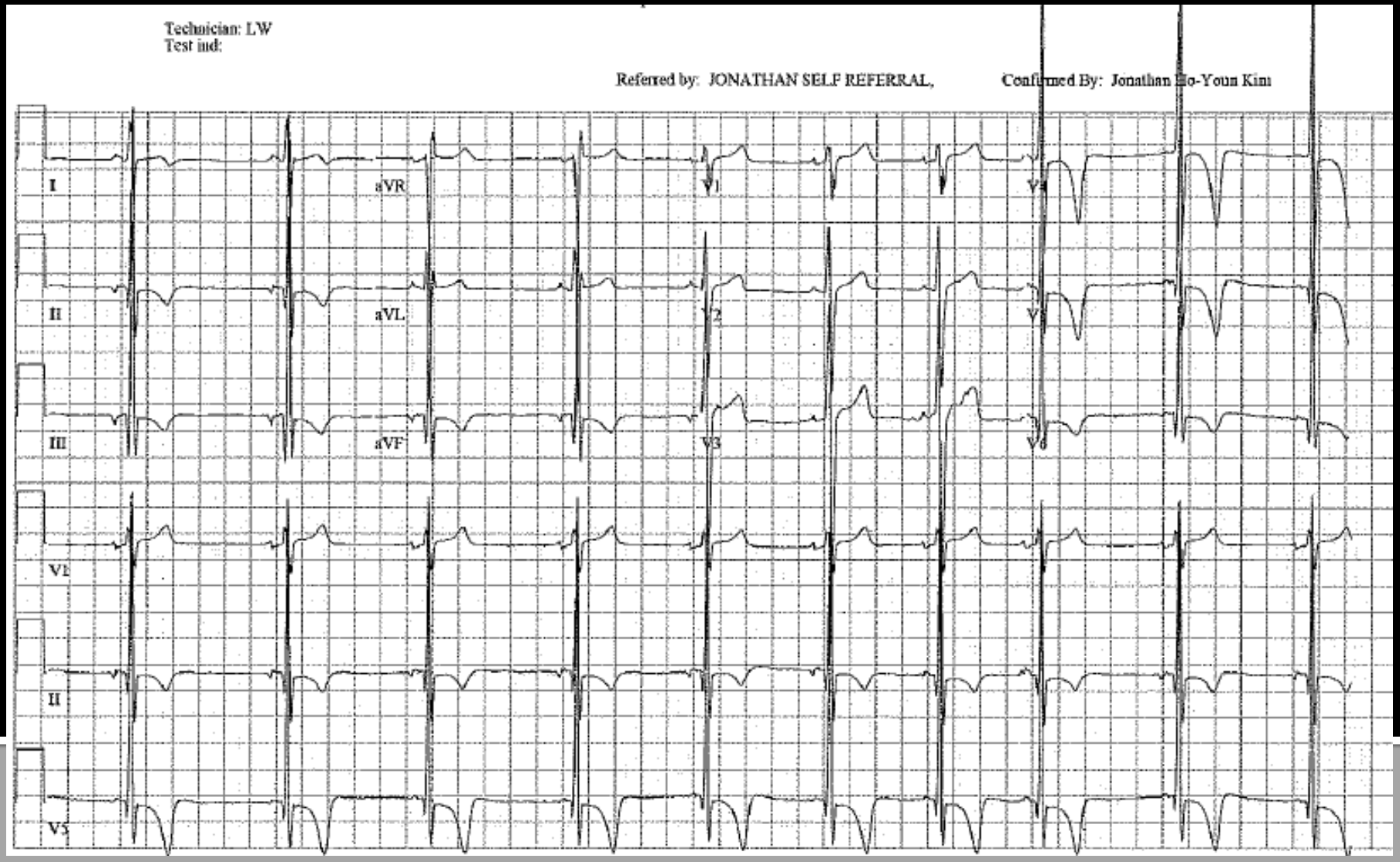
Hypertrophic Cardiomyopathy



Hypertrophic Cardiomyopathy

Asymmetric LVH with LVOT Obstruction (SAM)




Technician: LW
Test ind:
Referred by: JONATHAN SELF REFERRAL,
Confirmed By: Jonathan Eo-Youn Kim
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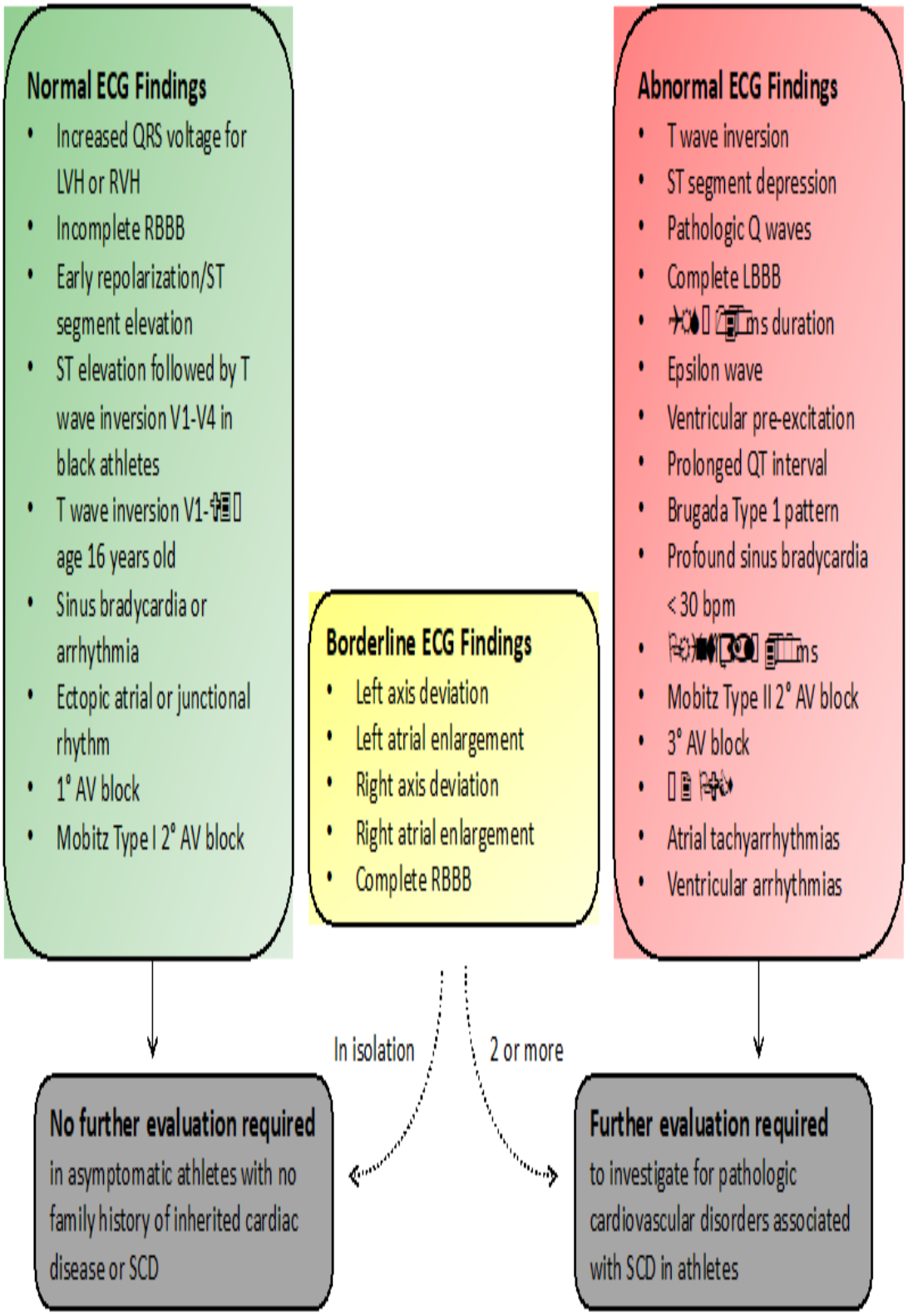
International Criteria for ECG Interpretation in Athletes



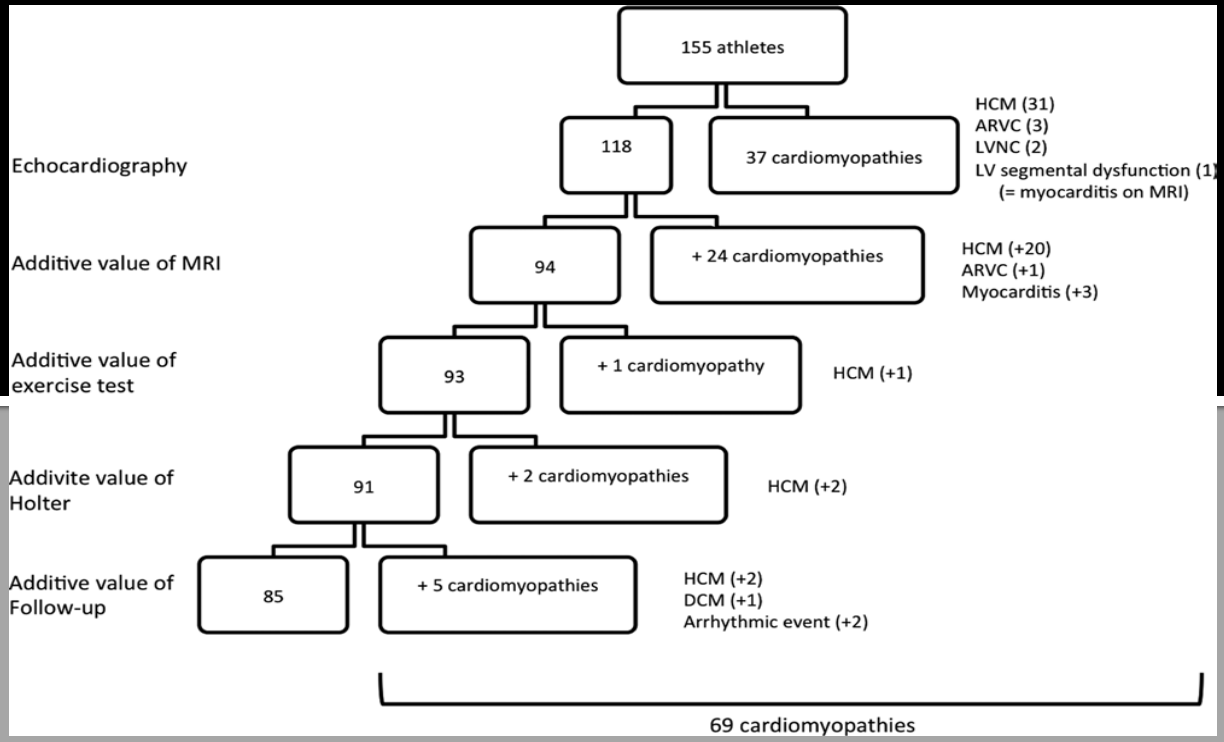
Sharma S. *J Am Coll Cardiol* 2017.

Are Inferolateral TWI Associated with a "Developing' Cardiomyopathy

- Database of 6,372 athletes, 155 (2.4%) with TWI (≥2 leads and 2 mm depth) accrued between 2008-2013
- 84% combination of inferior / lateral
- 45% with established cardiac disease
  - Echo diagnostic in 54% of positive cases, CMR additional 24 cases
- 5 (7.2%) progressed to CM (follow up 8-30 months)

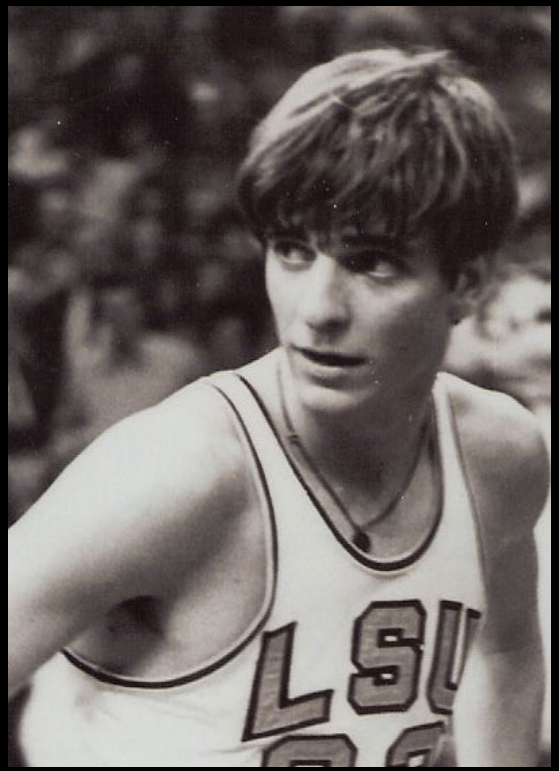
Circulation

Schnell F. *Circulation* 2015.

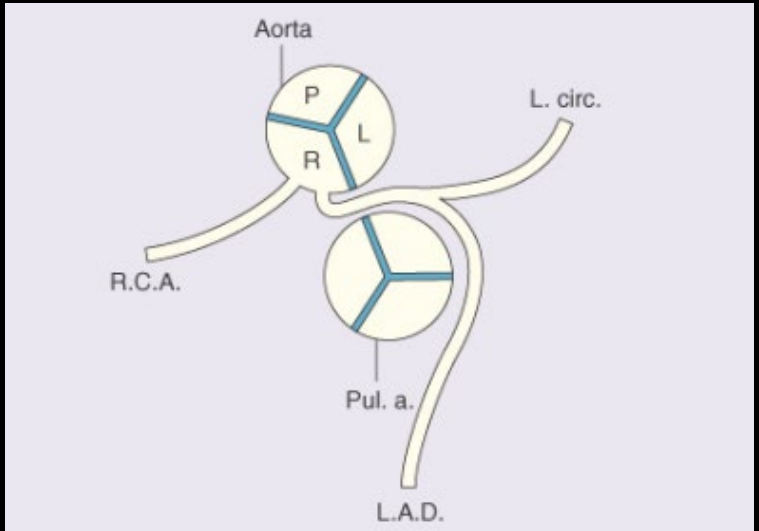


Congenital Coronary Anomalies

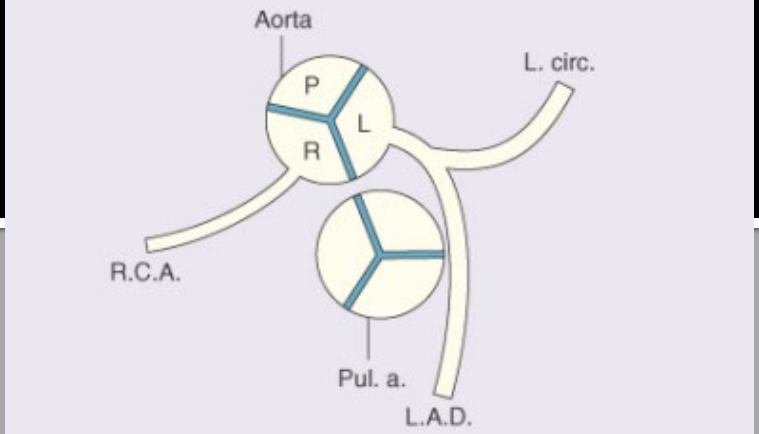
- Most common anomalies include the left coronary arising from the right sinus of Valsava and the right coronary arising from the left sinus of Valsava
- Diagnosis by ECG and echo is LIMITED, need high index of suspicion
- Gold standard for diagnosis: MRA/CTA



Congenital Coronary Anomalies



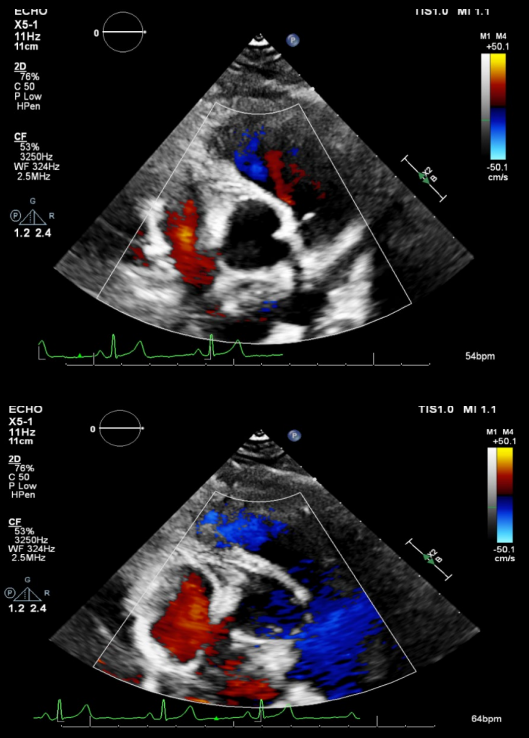
Anomalous origin left coronary artery from right (anterior) sinus of Valsalva

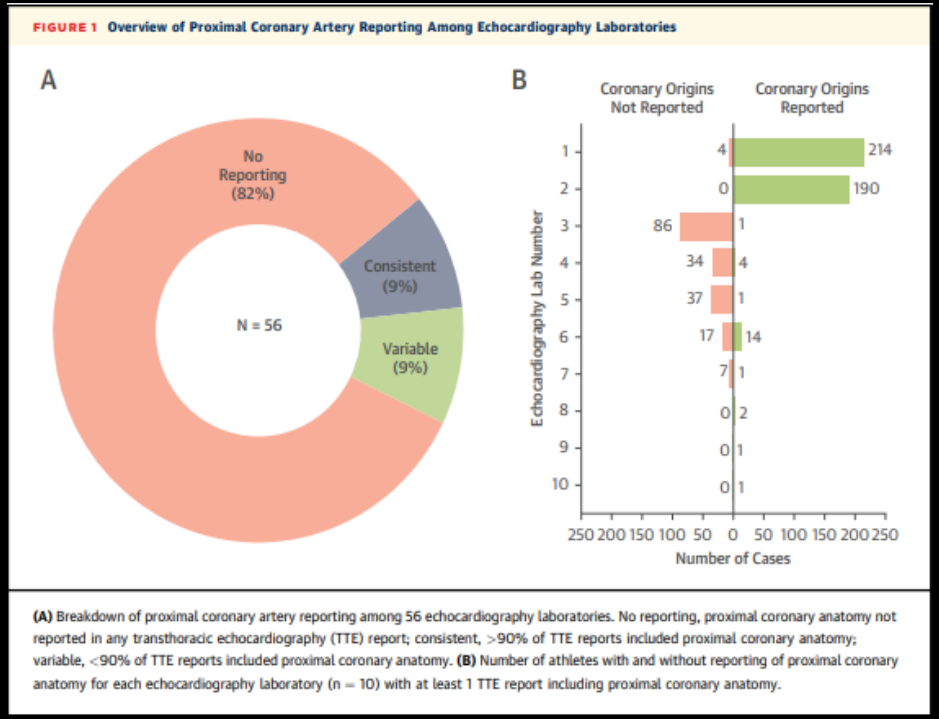


Normal

Congenital Coronary Anomalies

Outcomes Registry for Cardiac Conditions in Athletes (ORCCA)





Petek BJ. *JACC Cardiovasc Imaging* 2022

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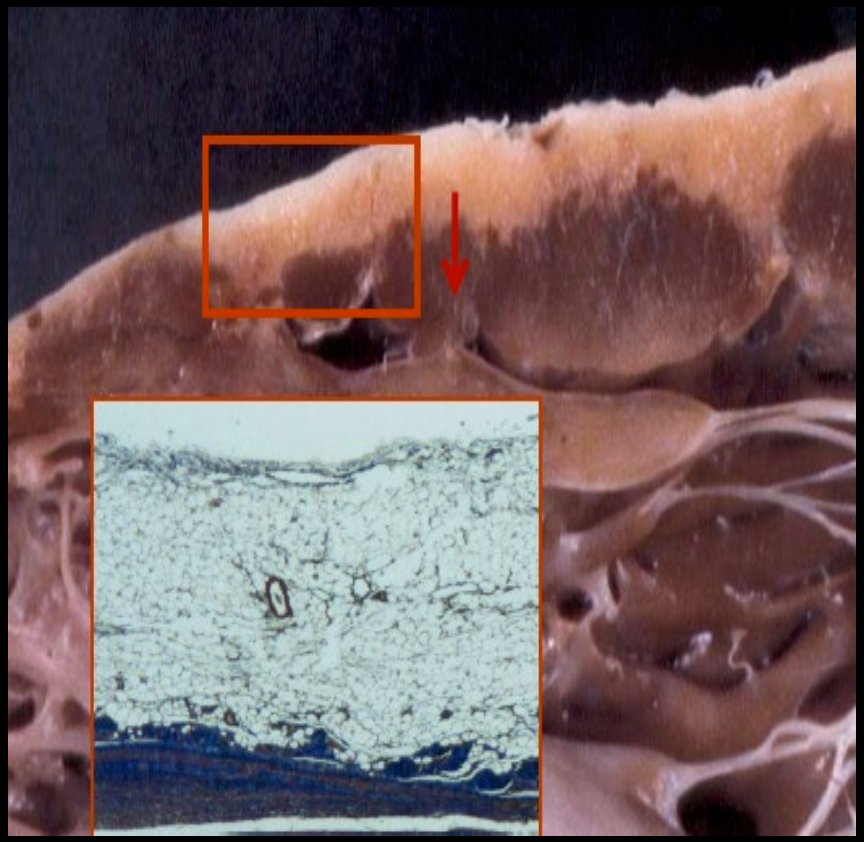
Arrhythmogenic Cardiomyopathy

- Fibro-fatty replacement of myocardium in the inflow tract, outflow tract, and/or apex of the RV
- Right ventricular dilatation, dysfunction, aneurysms
- Prevalence 1:5,000 in the general population
- Mutations in genes encoding cardiac desmosomal proteins
- 5-fold higher risk of SCD during competitive sports

Corrado D. *J Am Coll Cardiol* 2003.



Exercise Increases Age-Related Penetrance and Arrhythmic Risk in Arrhythmogenic Right Ventricular Dysplasia/Cardiomyopathy–Associated Desmosomal Mutation Carriers

Cynthia A. James, ScM, PhD, Aditya Bhonsale, MD, Crystal Tichnell, MGC, Brittney Murray, MS, Stuart D. Russell, MD, Harikrishna Tandri, MD, Ryan J. Tedford, MD, Daniel P. Judge, MD, Hugh Calkins, MD

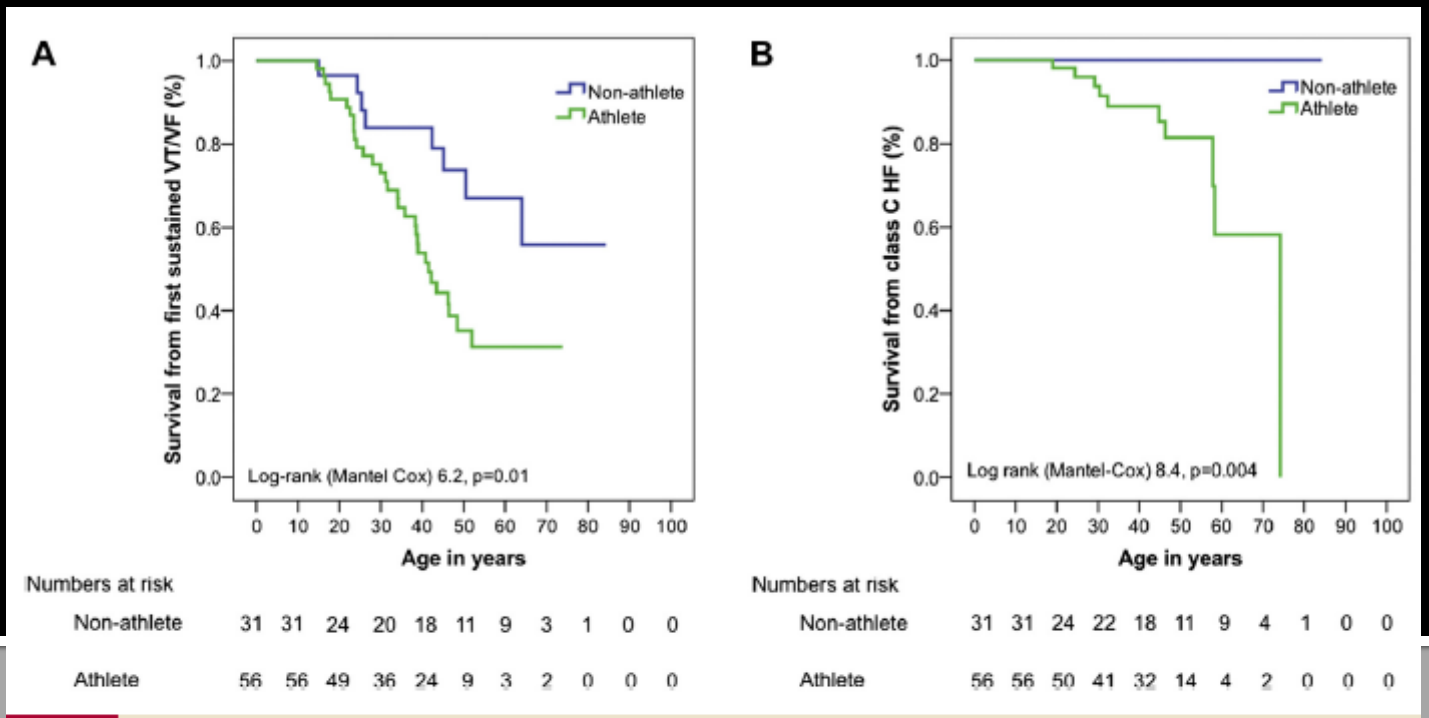
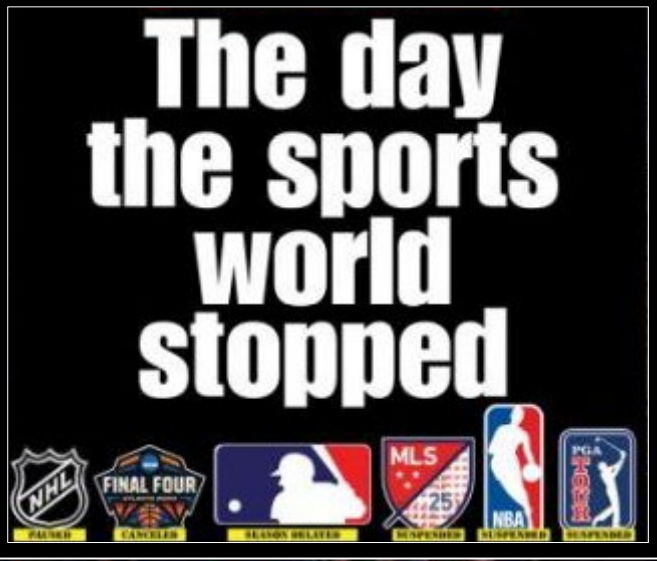


Figure 1 **Cumulative Lifetime Survival Free from Sustained Ventricular Arrhythmia and Class C Heart Failure**

Cumulative lifetime survival free of sustained ventricular arrhythmias **(A)** and stage C heart failure **(B)** stratified by participation in endurance athletics. Event-free survival from sustained arrhythmias and stage C heart failure is significantly lower among endurance athletes. HF = heart failure; VT/VF = ventricular tachycardia/ventricular fibrillation (sustained ventricular arrhythmia).

James CA. *J Am Coll Cardiol* 2013.

March 11th, 2020



Cardiac Injury Summary

- Cardiac injury is common with severe SARS-CoV-2 infection (hospitalized), ~17% (22% ICU)

  Driggin E. J Am Coll Cardiol 2020

- Worse outcomes with cardiac injury; cardiac injury more common in patients with underlying CV disease

  Guo T. JAMA Cardiol 2020

- Older patients with pre-existing co-morbidities and hospitalized at higher risk

  Driggin E. J Am Coll Cardiol 2020
  Guo T. JAMA Cardiol 2020
  Clerkin KJ. Circulation 2020

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VIEWPOINT

A Game Plan for the Resumption of Sport and Exercise After Coronavirus Disease 2019 (COVID-19) Infection

May 2020

Phelan D*, Kim JH*. JAMA Cardiol 2020

JAMA Cardiology | Special Communication

Coronavirus Disease 2019 and the Athletic Heart
Emerging Perspectives on Pathology, Risks, and Return to Play

Jonathan H. Kim, MD, MSc; Benjamin D. Levine, MD; Dermot Phelan, MD, PhD; Michael S. Emery, MD, MS; Mathew W. Martinez, MD; Eugene H. Chung, MD, MSc; Paul D. Thompson, MD; Aaron L. Baggish, MD

October 2020

Kim JH. JAMA Cardiol 2020

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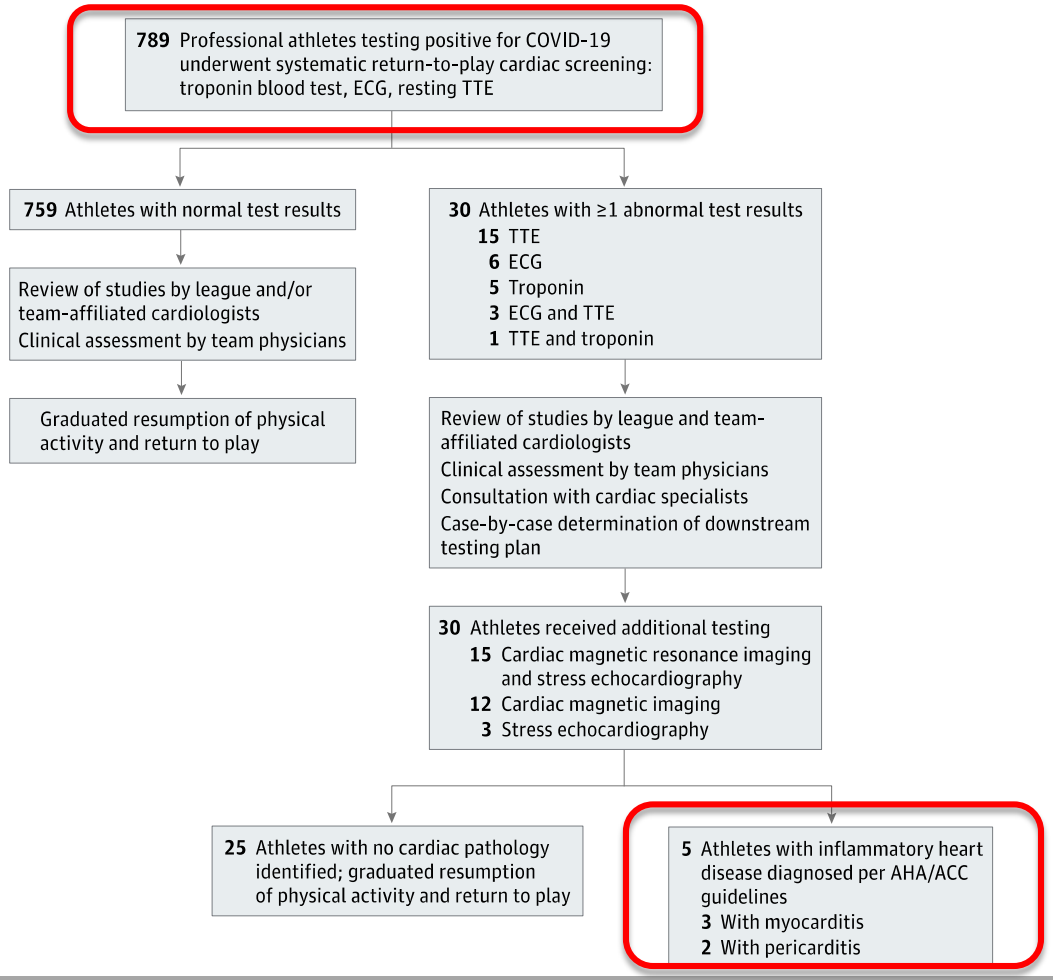
JAMA Cardiology | Original Investigation

Prevalence of Inflammatory Heart Disease Among Professional Athletes With Prior COVID-19 Infection Who Received Systematic Return-to-Play Cardiac Screening

Matthew W. Martinez, MD; Andrew M. Tucker, MD; O. Josh Bloom, MD, MPH; Gary Green, MD; John P. DiFiori, MD; Gary Solomon, PhD; Dermot Phelan, MD, PhD; Jonathan H. Kim, MD, MSc; Willem Meeuwisse, MD, PhD; Allen K. Sills, MD; Dana Rowe, BA; Isaac I. Bogoch, MD; Paul T. Smith, MD; Aaron L. Baggish, MD; Margot Putukian, MD; David J. Engel, MD

Figure. Flow Diagram of the Systematic Return-to-Play Cardiac Screening Process Used for Professional Athletes Testing Positive for Coronavirus Disease 2019 (COVID-19)



Martinez MW. JAMA Cardiol 2021

SARS-CoV-2 Cardiac Involvement in Young Competitive Athletes

Nathaniel Moulson, Bradley J. Petek, Jonathan A. Drezner, Kimberly G. Harmon, Stephanie A. Kliethermes, Manesh R. Patel, and Aaron L. Baggish
and for the ORCCA Investigators

Circulation

- 3,018 NCAA student athletes (42 universities, 19,378 tested) with COVID-19; majority tested with standard triad
- 198 with screening CMR
- **Cardiac involvement in 21/3,018 (0.7%)**; 6/198 (3%) with screening CMR
- CMR diagnostic yield 4.2x higher if clinically indicated study

Moulson N. Circulation 2021

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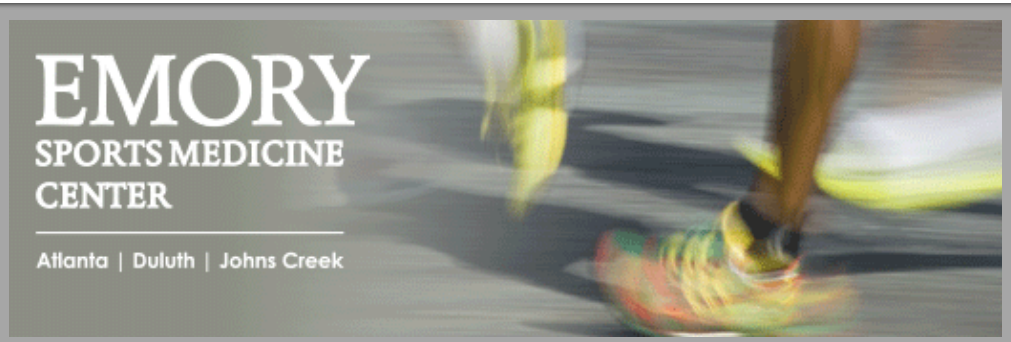
To Date, No Life-Threatening Adverse CV Events (COVID-19 Associated) Reported in Athletes Included in Registries after RTP



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Current Approach??

1. Asymptomatic, mild COVID-19, or moderate disease ***WITHOUT*** cardiopulmonary symptoms: CV risk stratification ***unnecessary***
2. If cardiopulmonary symptoms are present (or persistent), CV assessment warranted
3. More extensive testing (CMR) reasonable to consider with abnormal baseline tests, persistent/recurrent symptoms, but **NOT** as first line screening modality
4. Applies to any athlete, no differences by specific populations (ex. high school, Masters, etc.)

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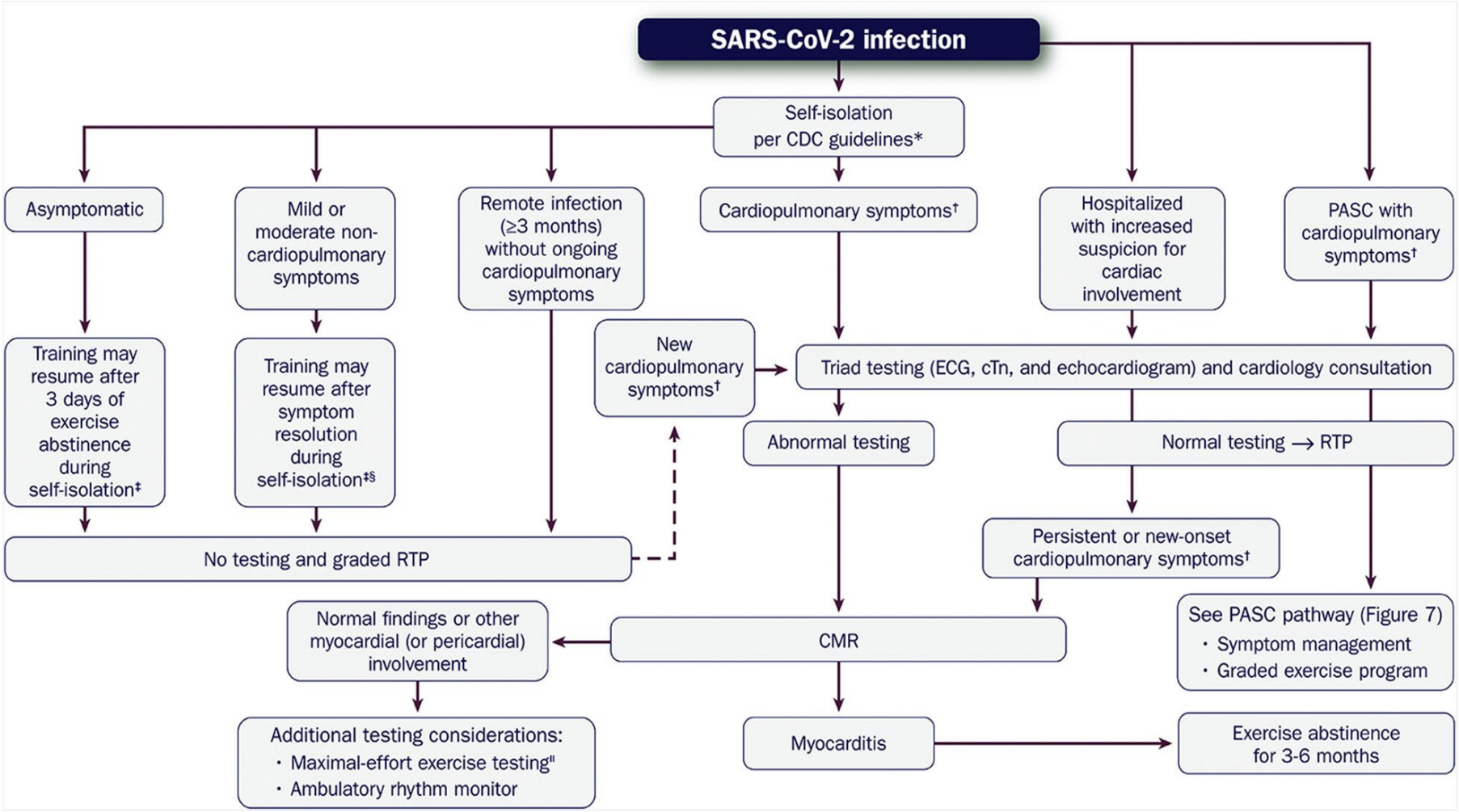
FIGURE 9 Evaluation of the Athletic Patient Convalesced From COVID-19 and Guidance on RTP and/or Intense Training



Gluckman TJ. *J Am Coll Cardiol* 2022

Myocarditis and Exercise Restrictions

- 3-6 months of exercise abstinence with confirmed myocarditis
- 11 athletes in Big 10 Registry with repeated CMR demonstrated resolution of all abnormal findings in median 8-weeks

Daniels CJ. *JAMA Cardiol* 2021

- RTP requires absence of symptoms, resolution of myocardial inflammation, normal LV function, absence of spontaneous or inducible cardiac arrhythmias

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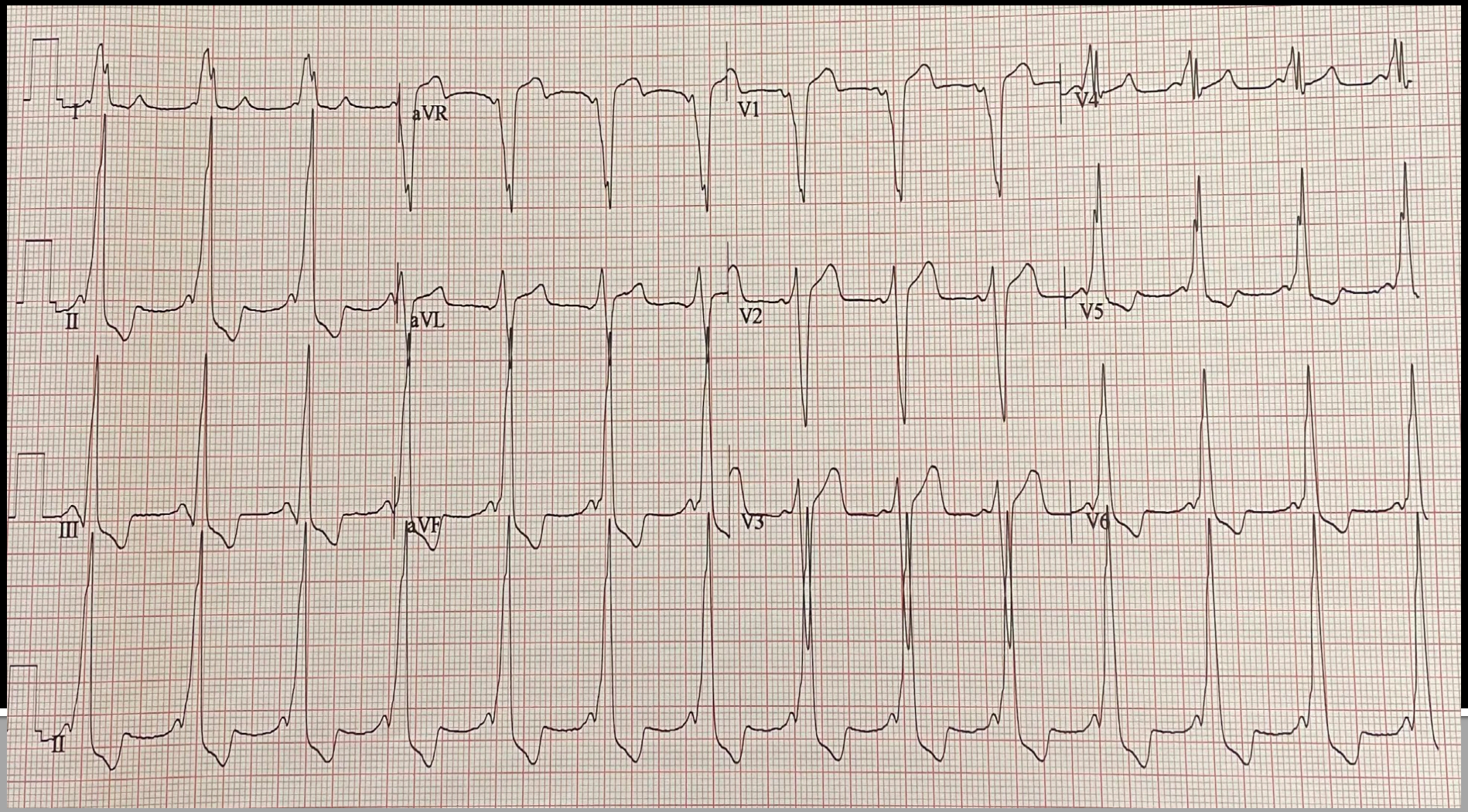
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III
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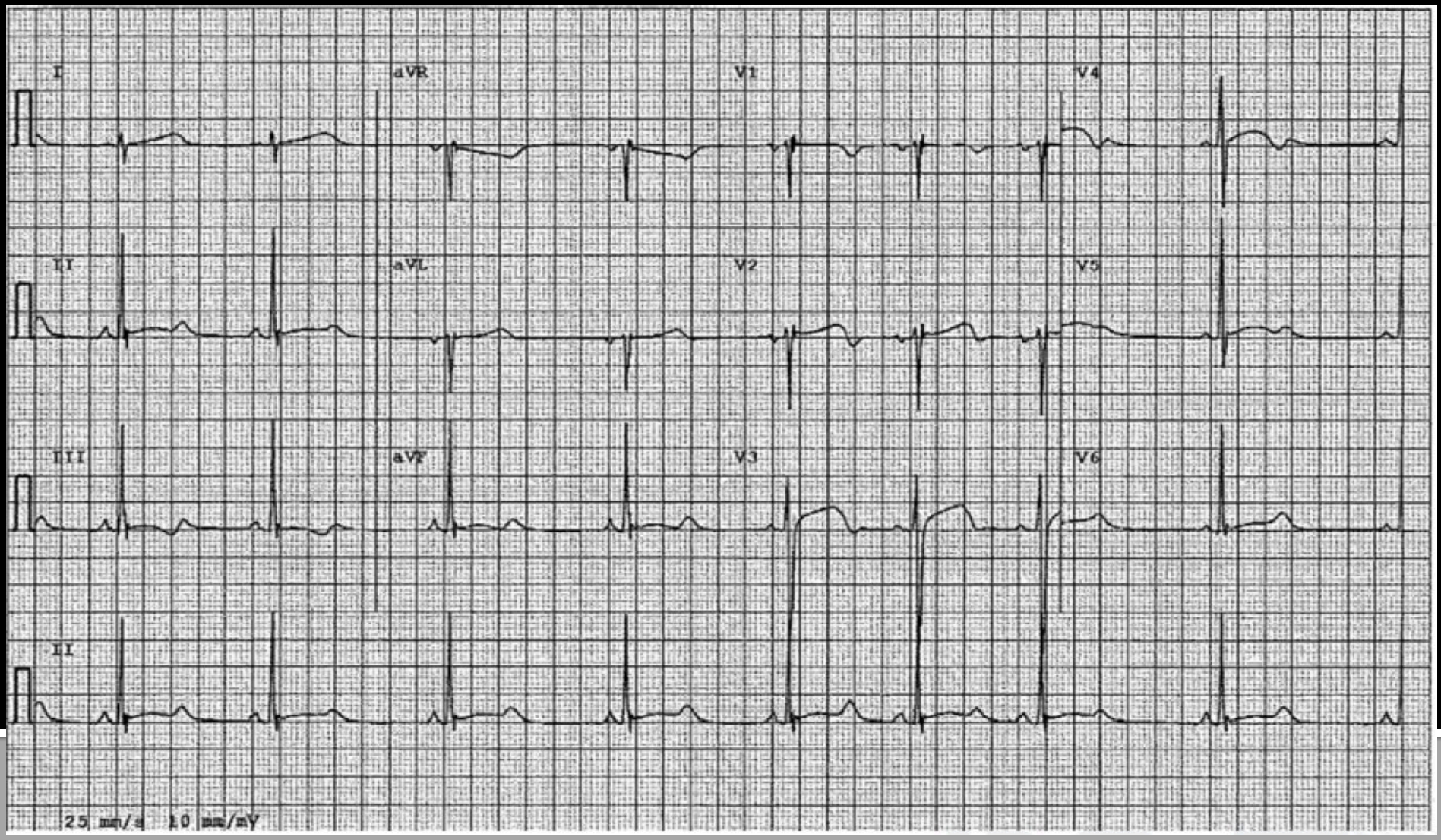
I
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III
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V3
V6
II
25 mm/s 10 mm/mV

Emergency Action Plan: Where There is No Debate

Core Principles of an EAP

EAP=Emergency Action Plan
SCA=Sudden Cardiac Arrest
CPR=Cardiopulmonary resuscitation
AED=Automated external defibrillator

Friedman EM. ACC.org

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STATE-OF-THE-ART PAPERS

Sports and Exercise Cardiology in the United States

Cardiovascular Specialists as Members of the Athlete Healthcare Team

Christine E. Lawless, MD,*† Brian Olshansky, MD,‡ Reginald L. Washington, MD,§
Aaron L. Baggish, MD,‖ Curt J. Daniels, MD,¶ Silvana M. Lawrence, MD, PhD,#
Renee M. Sullivan, MD,** Richard J. Kova
Chicago, Illinois; Lincoln, Nebraska; Iowa Ci
Columbus, Ohio; Houston, Texas; Columbia, M

JACC
JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY

THE PRESENT AND FUTURE

STATE-OF-THE-ART REVIEW

Sports Cardiology

Core Curriculum for Providing Cardiovascular Care to Competitive Athletes and Highly Active People

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Michael S. Em

Exercise-Induced Cardiovascular Adaptations and Approach to Exercise and Cardiovascular Disease

JACC State-of-the-Art Review

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The Landscaped Has Changed…

PERSPECTIVE

SHARED DECISION MAKING

Shared Decision Making — The Pinnacle of Patient-Centered Care

Michael J. Barry, M.D., and Susan Edgman-Levitan, P.A.

ONLINE FIRST

RESEARCH LETTER

Competitive Sports Participation in Athletes With Congenital Long QT Syndrome

Johnson, Ackerman

Detect, manage, inform: a paradigm shift in the care of athletes with cardiac disorders?

Jonathan A Drezner

Safety of Sports for Athletes With Implantable Cardioverter-Defibrillators

Results of a Prospective, Multinational Registry

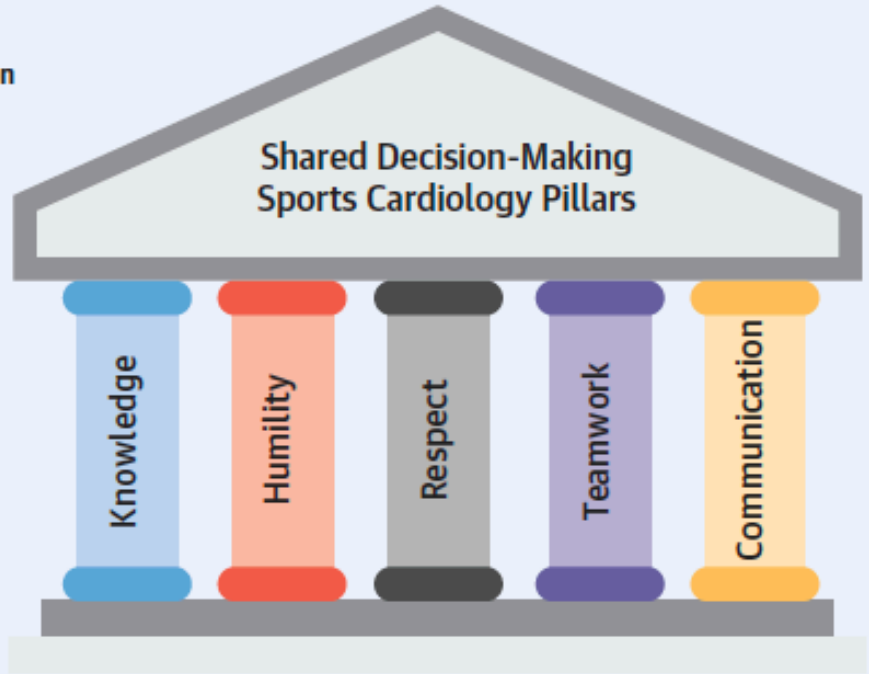
Rachel Lampert, MD; Brian Olshansky, MD; Hein Heidbuchel, MD; Christine Lawless, MD; Elizabeth Saarel, MD; Michael Ackerman, MD; Hugh Calkins, MD; N.A. Mark Estes, MD; Mark S. Link, MD; Barry J. Maron, MD; Frank Marcus, MD; Melvin Scheinman, MD; Bruce L. Wilkoff, MD; Douglas P. Zipes, MD; Charles I. Berul, MD; Alan Cheng, MD; Ian Law, MD; Michele Loomis, APRN; Cheryl Barth, BS; Cynthia Brandt, MD; James Dziura, PhD; Fangyong Li, MS; David Cannom, MD

The Landscaped Has Changed…

FIGURE 3 SDM Sports Cardiology Pillars

Knowledge
- Appropriate diagnosis
- Expertise in the cardiac condition
- Expertise in exercise and sport recommendations

Humility
- Recognize you may not be able to provide expert counsel
- Additional opinions serve both patient and provider
- Recognize that the science can change
- Appreciate that the physician is there to serve the patient



Respect
- Respect patient priorities
- Recognize the patient's voice and opinion

Teamwork
- Approach the patient as a teammate and fellow "expert"
- Engage and discuss with patient significant others
- Engage coaches and team medical personnel to optimize the sports environment

Communication
- Document discussion of risk/ benefits of participation and restriction
- Communicate with all stakeholders

Martinez MW. *J Am Coll Cardiol* 2021

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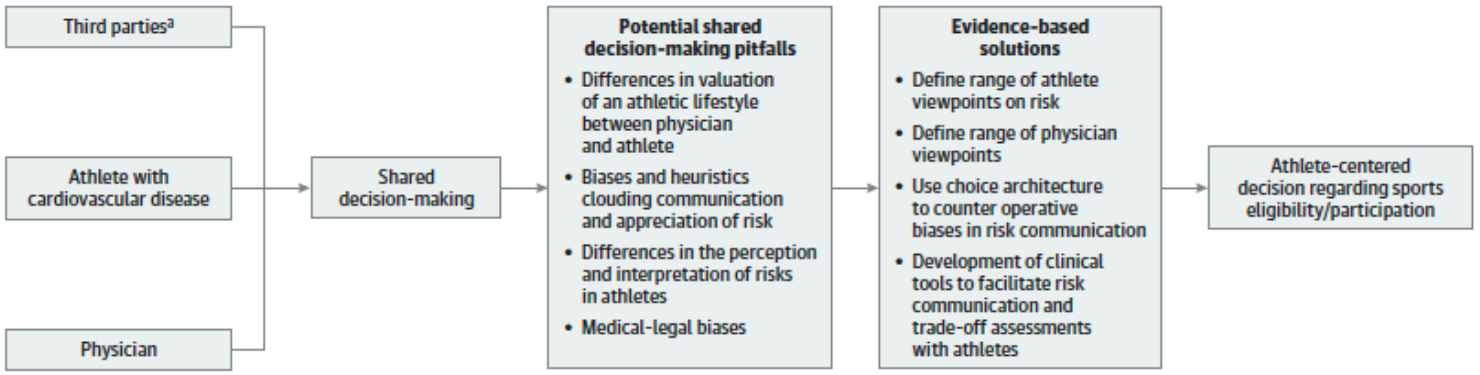
VIEWPOINT

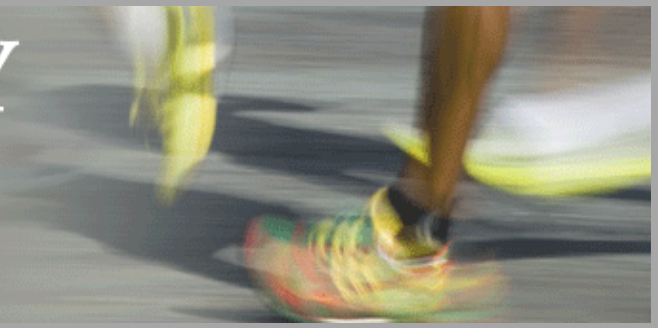
Athletes With Cardiovascular Disease and Competitive Sports Eligibility Progress and Challenges Ahead

Figure. Key Conceptual Pitfalls and Proposed Evidence-Based Solutions in Achieving a Balanced Athlete-Centered, Shared Decision-making Outcome



[a] Third parties are specific to competitively sanctioned athletes and represented by governing sporting leagues or organizations, universities, agents, or other family members.

Kim JH. *JAMA Cardiol* 2022



Outcome Registry for Cardiac Conditions in Athletes

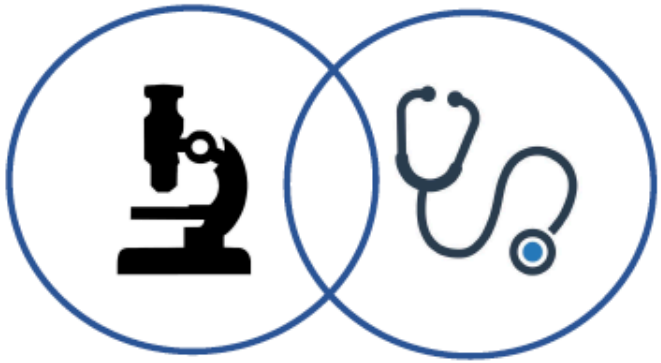
AMSSM
AMERICAN MEDICAL SOCIETY FOR SPORTS MEDICINE

American Heart Association®

A Call for *Action* and *Inclusion* in Sports Cardiology

Research & Science

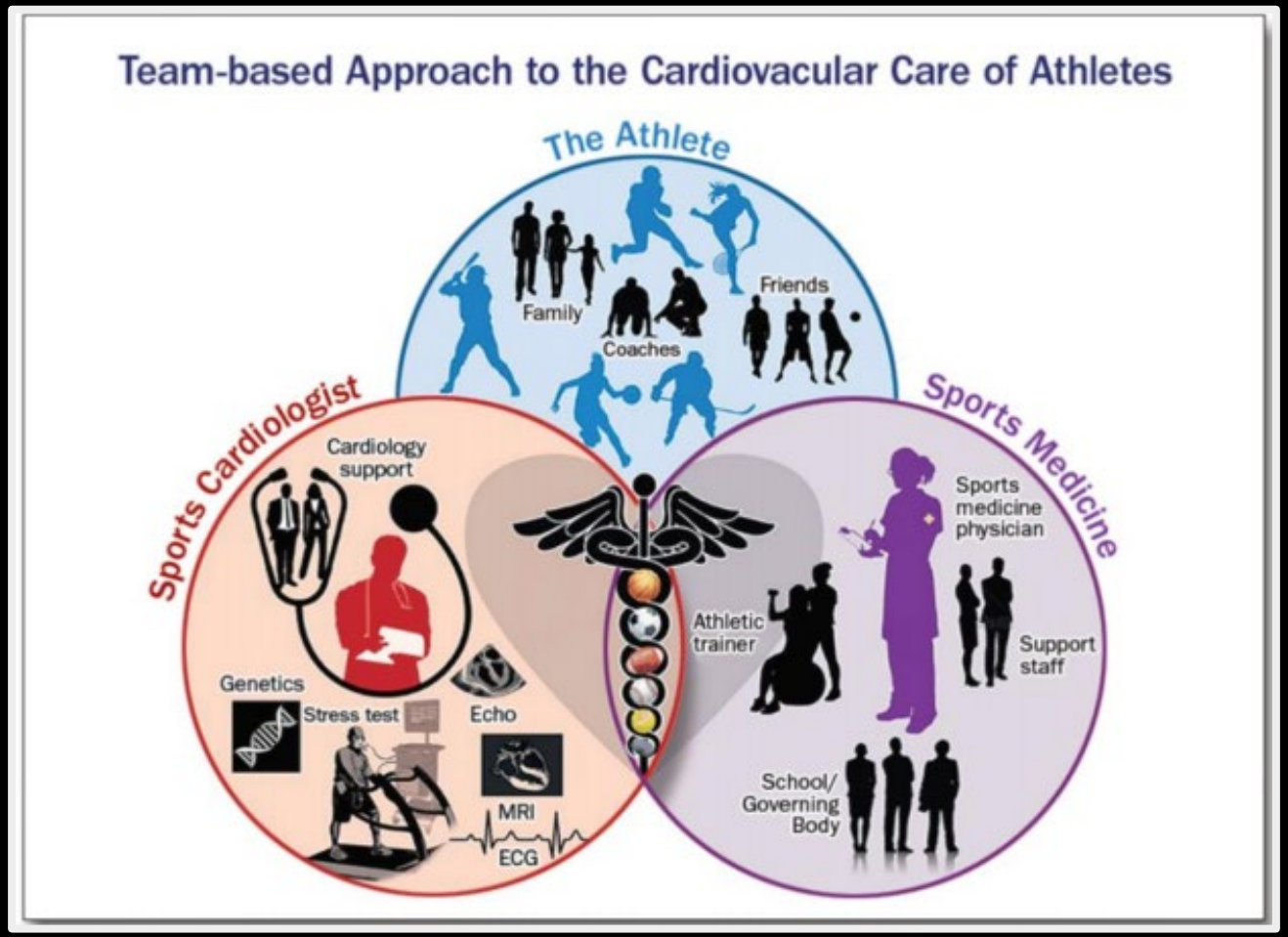
- Appreciate race as a social construct, not biologic
- Increase diversity within sports cardiology outcomes and observational studies
- Include social determinants of health in outcomes and observational studies of athletes
- Consider unique athlete social 'stressors' and experiences with racism and discrimination



Clinical Care

- Increase workforce diversity
- Promote cultural competency training for practitioners
- Acknowledge & resolve the presence of implicit biases
- Eradicate race-based practices (e.g., 'Afro-Caribbean ECG pattern') within sports cardiology
- Standardize cardiac screening protocols for athletes

Figure prepared by Grant AJ, Krishnan S, Chukumerije M, Guseh JS, Kim JH



Emery MS. *JACC Heart Fail* 2018.

Areas of Emphasis… We've Only Just Begun!

1. Focus on OUTCOMES of athletes with CV risk and disease
2. Focus on QUALITY- do you trust your sports/team cardiologist? We must focus on education, quality metrics and access
3. Focus on LONGITUDINAL ASSESMENTS of athletes
4. Focus on RESEARCH on areas of clinical uncertainty
5. Focus on SHARED DECISION-MAKING
6. Focus on messaging EMERGENCY ACTION PLANNING
7. Focus on CHALLENGES looking ahead (disparities)

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THANK YOU

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