Cleveland Clinic

Care of the Athletic Heart

March 28rd 2018

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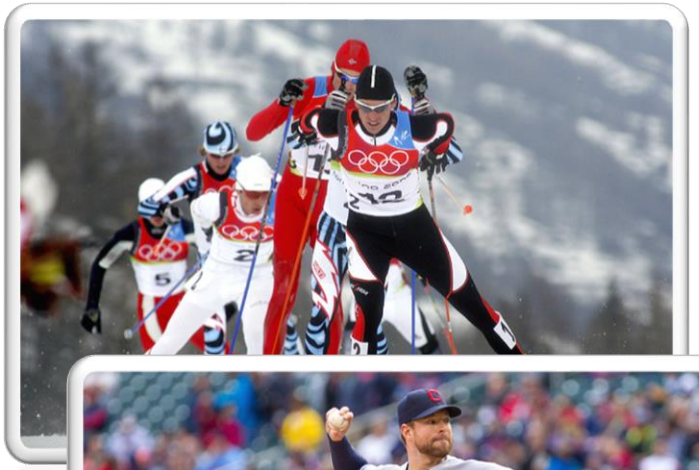
Cleveland Cavaliers Cardiologist,
Staff Cardiologist,
Heart and Vascular Institute
Cleveland Clinic

No Disclosures

The Athlete is a Unique CV Patient



How do we define an athlete?

“One who participates in an organized team or individual sport that requires regular competition against others as a central component, places a high premium on excellence and achievement, and requires some form of systematic (and usually intense) training.”

Sports and Exercise Cardiology Section & Leadership Council

A section for all interested in sports and exercise cardiology, open to all ACC members with an interest in the cardiovascular care of the athlete and exercising individuals of all ages.

Sports & Exercise Cardiology
MEMBER SECTION

ESC European Society of Cardiology

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European Association of Preventive Cardiology (EAPC)

Sports Cardiology Section

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Appointments 800.659.7822

APPOINTMENTS & LOCATIONS

CHAT WITH A HEART & VASCULAR NURSE

CONTACT US

SHARE

Care of the Athletic Heart:
A comprehensive Sports Cardiology Program.

Pre-participation screening

Exercise induced cardiac remodeling vs cardiac pathology

Discuss risk of extreme exercise

Evaluate the symptomatic athlete

Manage athletes with CV disease

Are athletes at higher risk of sudden cardiac death than their sedentary counterparts?

Are athletes at higher risk of sudden cardiac death than their sedentary counterparts?

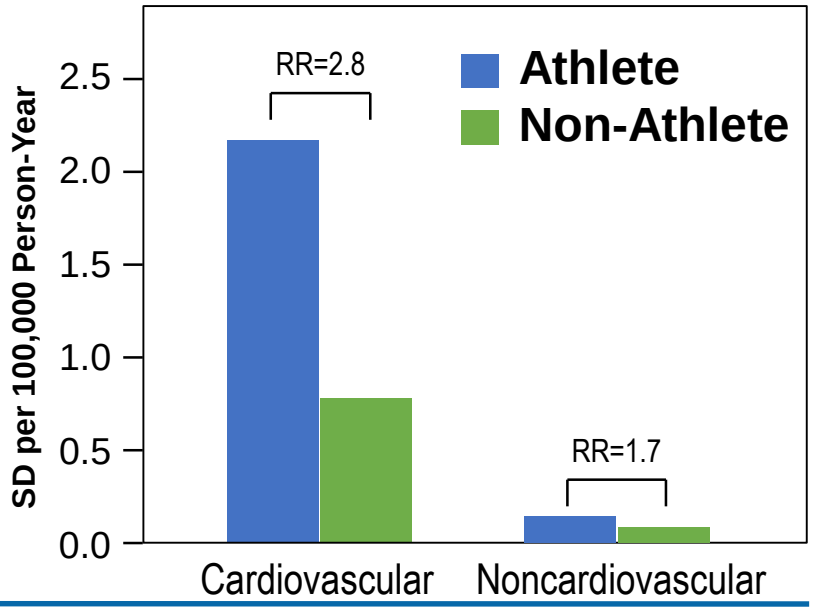
Journal of the American College of Cardiology

Published by Elsevier Inc.

Does Sports Activity Enhance the Risk of Sudden Death in Adolescents and Young Adults?

Domenico Corrado, MD, PHD,* Cristina Basso, MD, PHD,† Giulio Rizzoli, MD,‡ Maurizio Schiavon, MD,§ Gaetano Thiene, MD†
Padua, Italy

- 21 year prospective study 1979-1999
- ~1.3 million between ages of 12-35 years
- 300 SCD cases
  - 55 athletes (2.3:100,000/yr)
  - 245 non-athletes (0.9:100,00/yr)



What is the risk of sports related sudden cardiac death?

- The true incidence of SrSCD is controversial with estimates ranging from 0.12 to 13/100,000 person-years (PY).

- Calculated incidence depends on the **numerator** and method of identifying this number: media reports and insurance claims have been shown to underestimated the true incidence.

- Depends on the **denominator** – often estimated from surveys and census documents.

What is the risk of sports related sudden cardiac death?

- Meta-analysis of 21 studies showed the incidence of SrSCD was 0.72 (95% CI 0.58-0.86) per 100,000 PY (~1 in 140,000).[1]
- No significant difference between USA v Europe, prospective or retrospective studies, high school/collegiate vs others.[1]
- Differs greatly in certain sub-groups:
  - Men are 10-20 times more likely to suffer SCD than women
  - SrSCD is 3-5 times more common in black versus white athletes
  - Reported incidence of SCD in Division one black basketball players is high as 1:5200.[2]

[1] Mahananey et al JACC 2017
[2] Harmon et al Circulation 2015

Comparison of Pre-Participation Evaluations

	Components	Last updated	ECG recommended
AHA: 14-element recommendations for pre-participation screening of competitive athletes	Personal history Family history Physical Examination	2014	No
Pre-participation Physical Evaluation Monograph 4th Edition	Personal history Family history Physical Examination	2010	+/-
ESC Questionnaire and Physical Examination Components for Pre-Participation Cardiovascular Screening of Competitive Athletes.	Personal history Family history Physical Examination	2005	Yes

Considerations

- No questions are evidence based – all are based on consensus opinion.
- 24-43% of college athletes and 68% of high-school athletes answered positively to at least one PPE question.
- High postive responses create medicolegal dilemma – No standardized follow up questions.
- Downstream testing is not standardized.
- No details on how to perform physical examinations.
- No data showing screening with a H&P reduces the risk of SCD on athletes.

The effectiveness of screening history, physical exam, and ECG to detect potentially lethal cardiac disorders in athletes: A systematic review/meta-analysis

Kimberly G. Harmon, M.D.,[a, b,*] Monica Zigman, M.P.H.,[a] Jonathan A. Drezner, M.D.[a]

[a] *Department of Family Medicine, University of Washington, Seattle, WA, USA*

[b] *Department of Orthopaedics and Sports Medicine, University of Washington, Seattle, WA, USA*

15 studies with ~47,000 athletes screened.

Meta-Analysis of Pooled Data

	History	Physical
Sensitivity	**20% (7%-44%)**	**9% (3%-24%)**
Specificity	**94% (89%-96%)**	**97% (95-98%)**

Harmon et al. Journal of Electrocardiology 2015

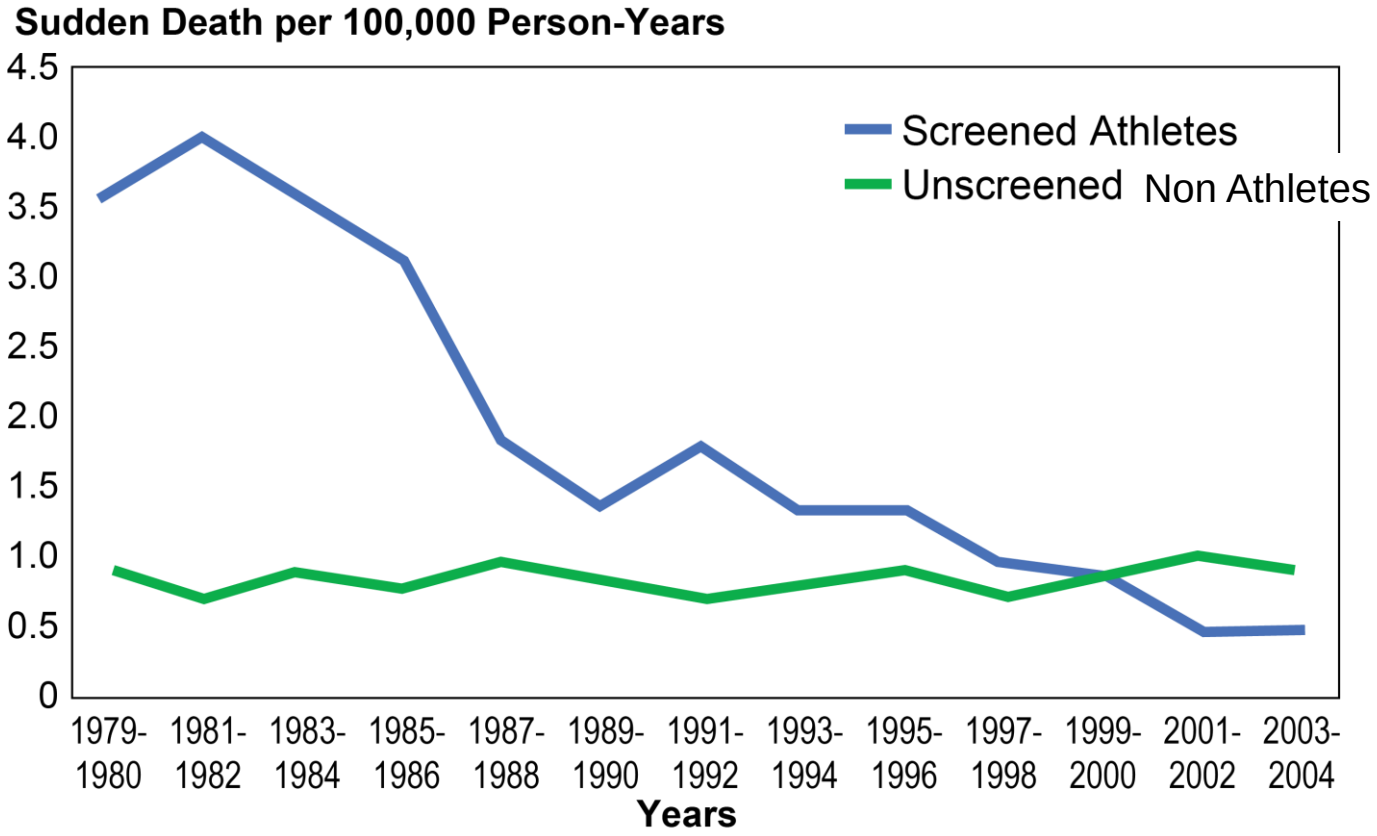
How does ECG perform?

Meta-Analysis of Pooled Data

	ECG
Sensitivity	**94% (79%-98%)**
Specificity	**93% (90%-96%)**

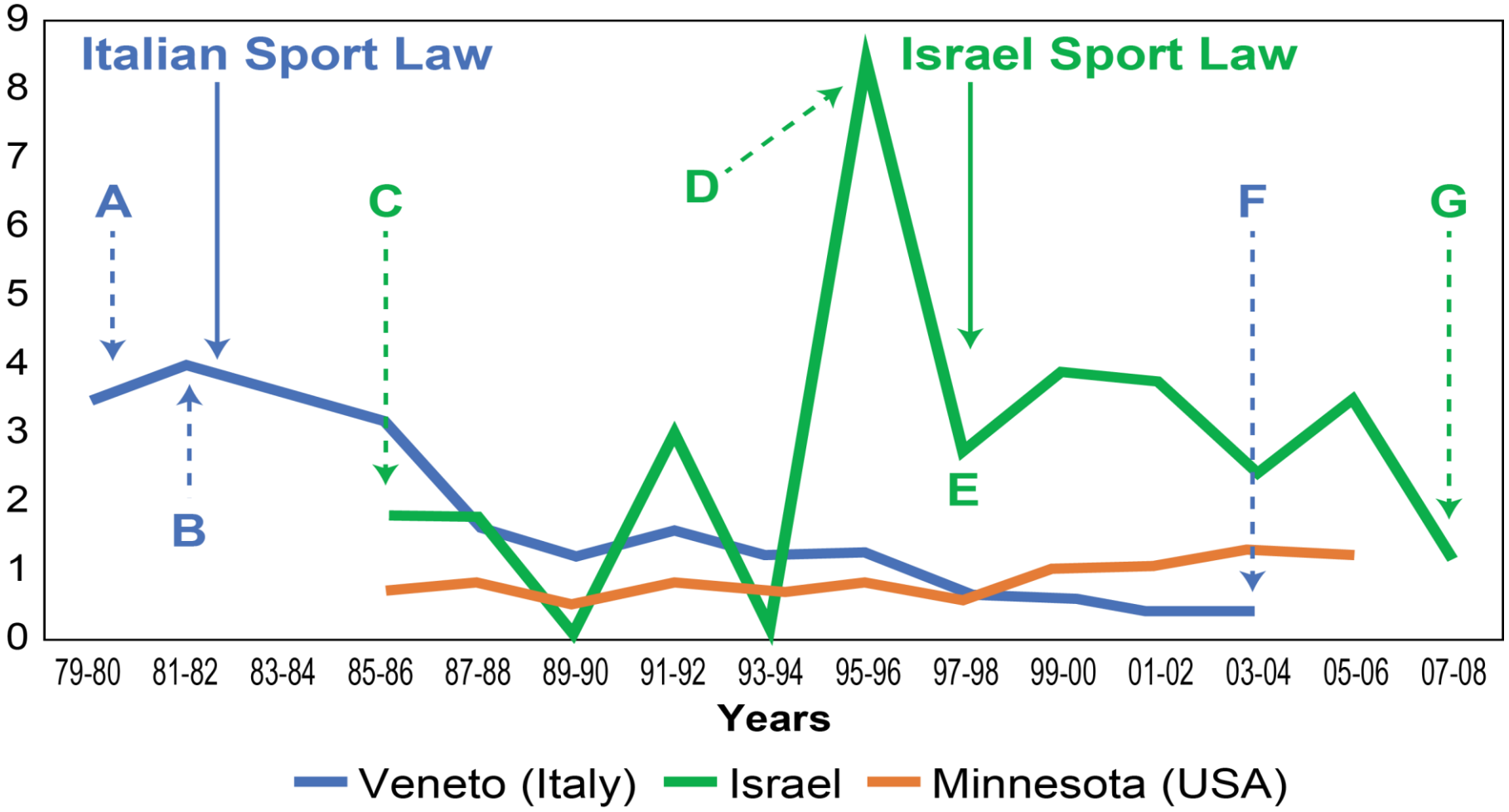
Harmon et al. Journal of Electrocardiology 2015

Does screening using ECG reduce the risk of SCD?



Corrado et al JAMA 2006

May not be that simple?



Considerations

- Meta-analysis of ~47,000 athletes revealed 0.3% of athletes had a potentially life threatening disease (1 in 294) identified.[1]
- In the Veneto region 2% of athletes were disqualified.[2]

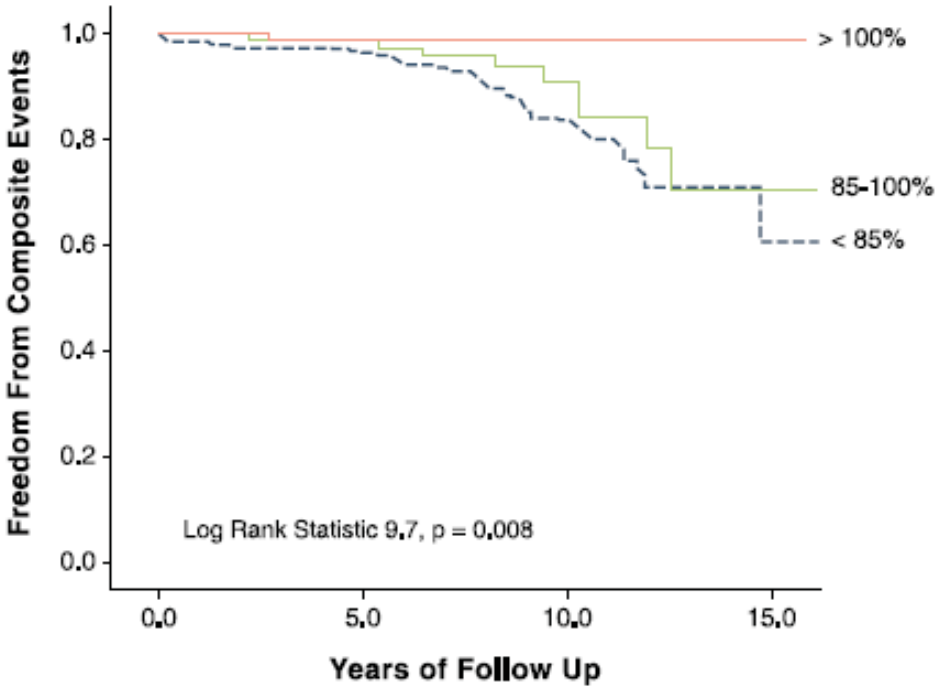
- Number of athletes found to have a cardiac pathology based on positive ECG much higher than risk of SCD – many athletes will receive apparently appropriate but ultimately unnecessary interventions.

[1] Harmon et al Journal of Electrocardiology 2015
[2] Corrado et al JAMA 2006

Exercise Paradox

- In normal individuals and those with heart disease the risk of cardiac arrest is transiently increased during vigorous exercise, but habitual exercise is associated with an overall decreased mortality.

HOCM



Desai M JACC imaging 2014

Evolution of Guidelines for the Interpretation of ECG's in the Athlete

Arbitrary Classification of Abnormal findings on ECG

ESC Guidelines 2010

Seattle Criteria 2012

Refined Criteria 2014

International Recommendations 2017

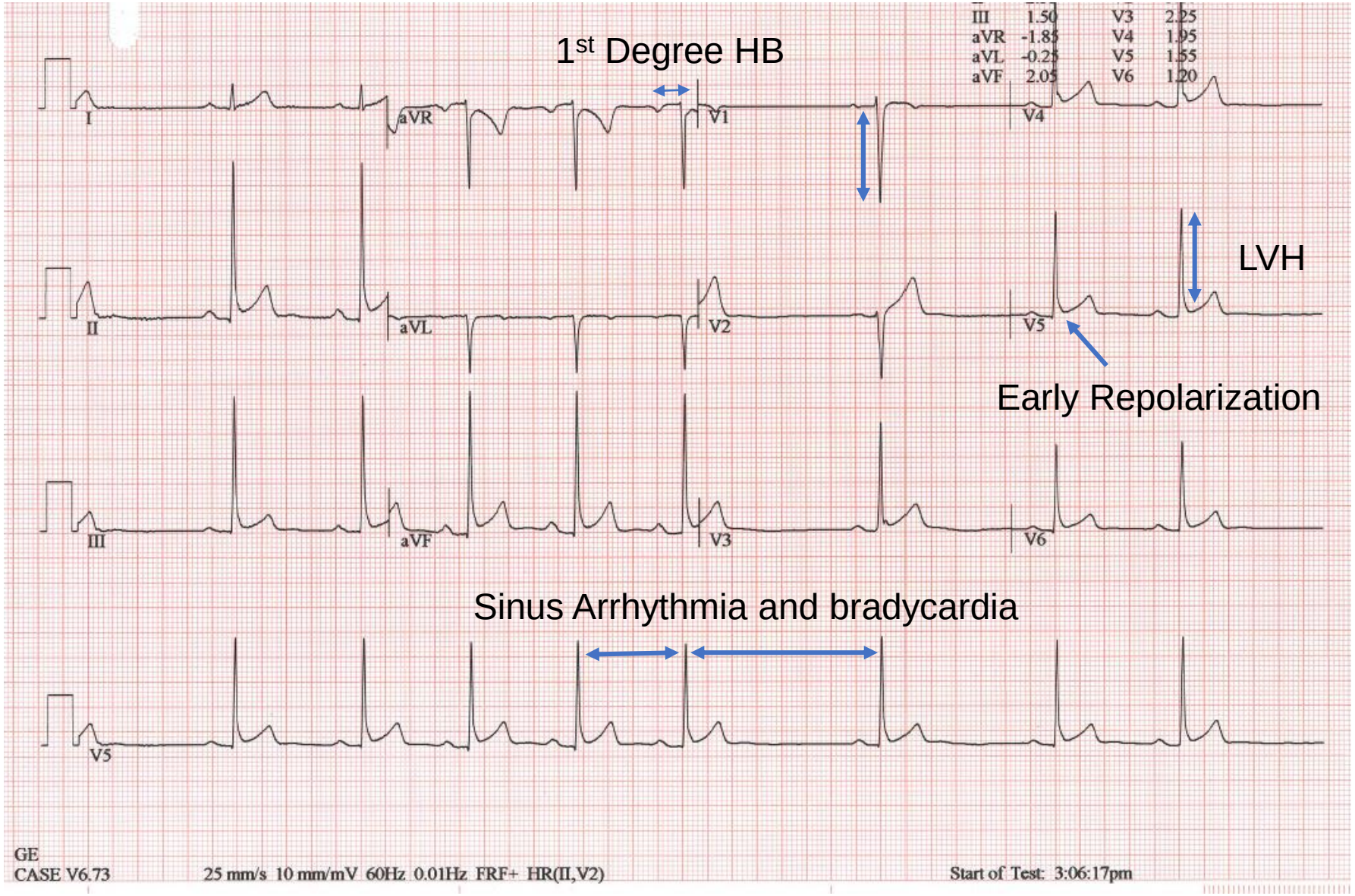
ECG Changes in Athletes

Vagotonia

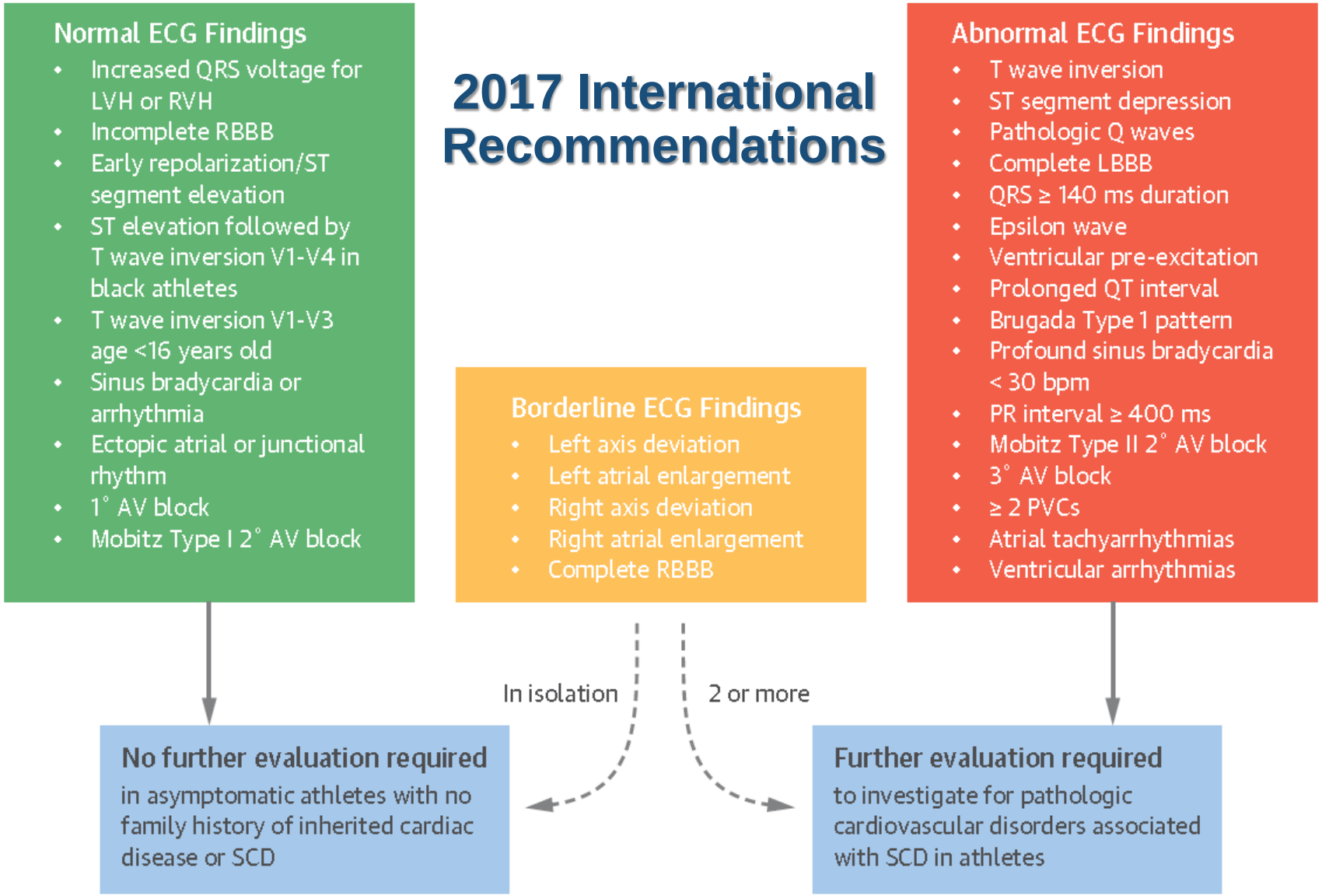
- 1st degree HB ~5-13%
- Sinus brady ~80%
- Sinus arrhythmia ~70%
- Mobitz Type 1, ~30%
- Junctional rhythm, ~20%
- Sinus pauses, ~40%
- Early Repol, ~60%

Morphological Changes

- LVH, ~70%
- LAE
- RAE
- Partial RBBB, ~30%


1st Degree HB
LVH
Early Repolarization
Sinus Arrhythmia and bradycardia
III 1.50
aVR -1.85
aVL -0.25
aVF 2.05
V3 2.25
V4 1.95
V5 1.55
V6 1.20
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V5
GE
CASE V6.73
25 mm/s 10 mm/mV 60Hz 0.01Hz FRF+ HR(II,V2)
Start of Test: 3:06:17pm

2017 International Recommendations



Sharma et al JACC/EHJ 2017

Interassociation consensus statement on cardiovascular care of college student-athletes

- PPE is performed to identify conditions that may put the student-athlete at **unreasonable risk of death or catastrophic injury** with the potential to modify and reduce the risk through individualized management.

- Process should be formalized and in writing
  - Clear roles
  - Management of medical records.

Hainline B et al BMJ/JACC 2016

Interassociation consensus statement on cardiovascular care of college student-athletes

- In addition, the PPE can be used to:
  - Ensure current health problems are being managed appropriately.
  - Identify conditions that serve as barriers to performance.
  - Opportunity to build a relationship between student and people involved in medical care.
  - Assess for characteristics that increase risk of future injury.
  - Review medications and supplements.
  - Educated regarding health risks, health related behaviour and pertinent issues regarding safe play.

Hainline B et al BMJ/JACC 2016

Interassociation consensus statement on cardiovascular care of college student-athletes

- Recommend either AHA 14 element or 4th monograph +/- ECG
- If ECGs are to be performed:
  - Decide a priori who will be screened.
  - Identify a CV specialist who will coordinate.
  - Provide information to the athlete regarding rationale for ECG testing and possible risks and benefits.
  - Interrpret with modern standards.
  - Skilled cardiology oversight required.

Hainline B et al BMJ/JACC 2016

Interassociation consensus statement on cardiovascular care of college student-athletes

- "The management of identified cardiac disorders and all sport eligibility decisions are ultimatedly the responsibility of the **institutional primary athletics healthcare providers** in consultation with **subspecialty consultants**."

Hainline B et al BMJ/JACC 2016

Care of the Athletic Heart:
A comprehensive Sports Cardiology Program.

Pre-participation screening

Exercise induced cardiac remodeling vs cardiac pathology

Discuss risk of extreme exercise

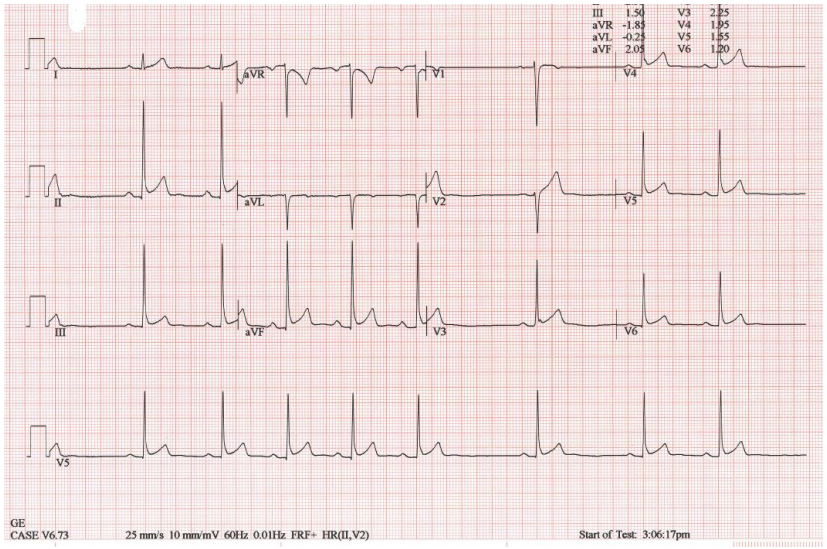
Evaluate the symptomatic athlete

Manage athletes with CV disease

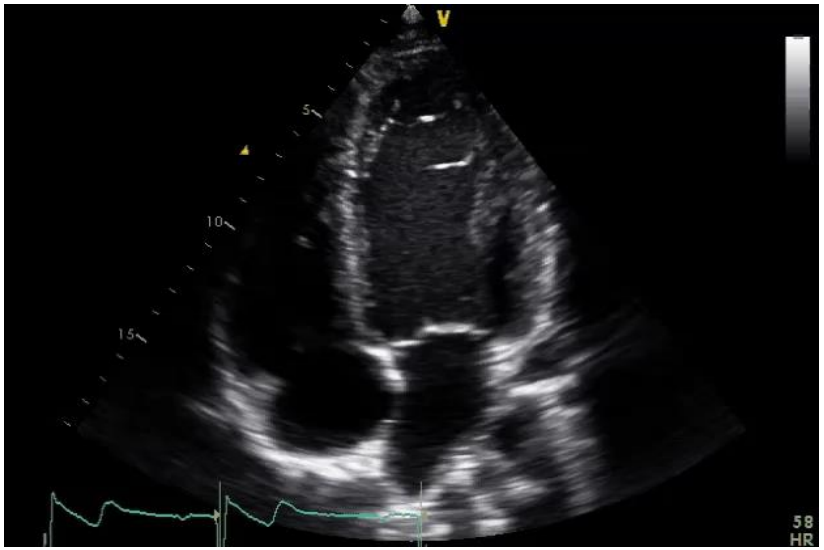
Athletic Heart

- Athlete's Heart (Syndrome) refers to **physiological** cardiac changes that occur as a result the **hemodynamic stress** of regular strenuous exercise.

Electrical

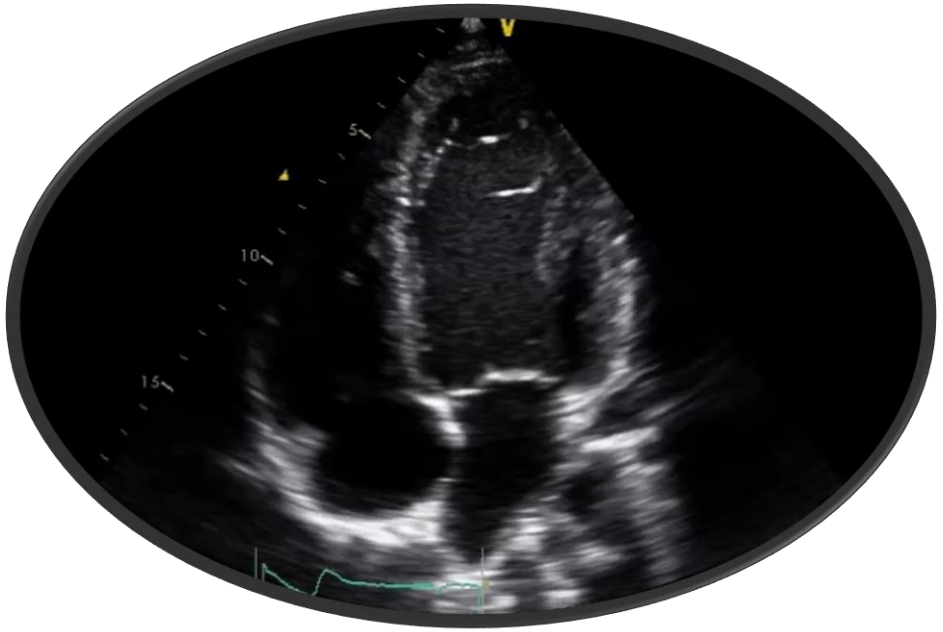


Functional and Morphological

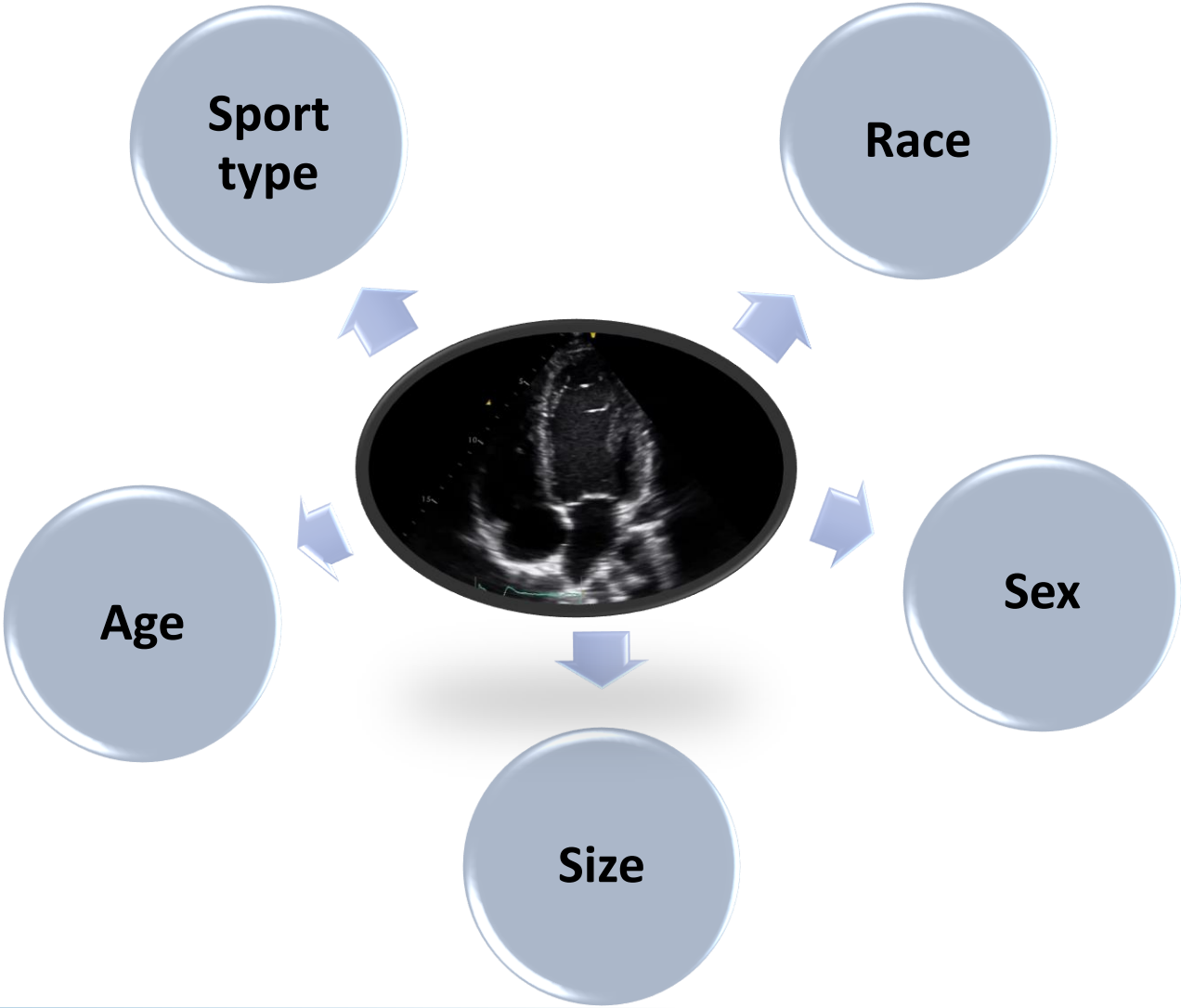


Morphological Changes of the Athlete's Heart

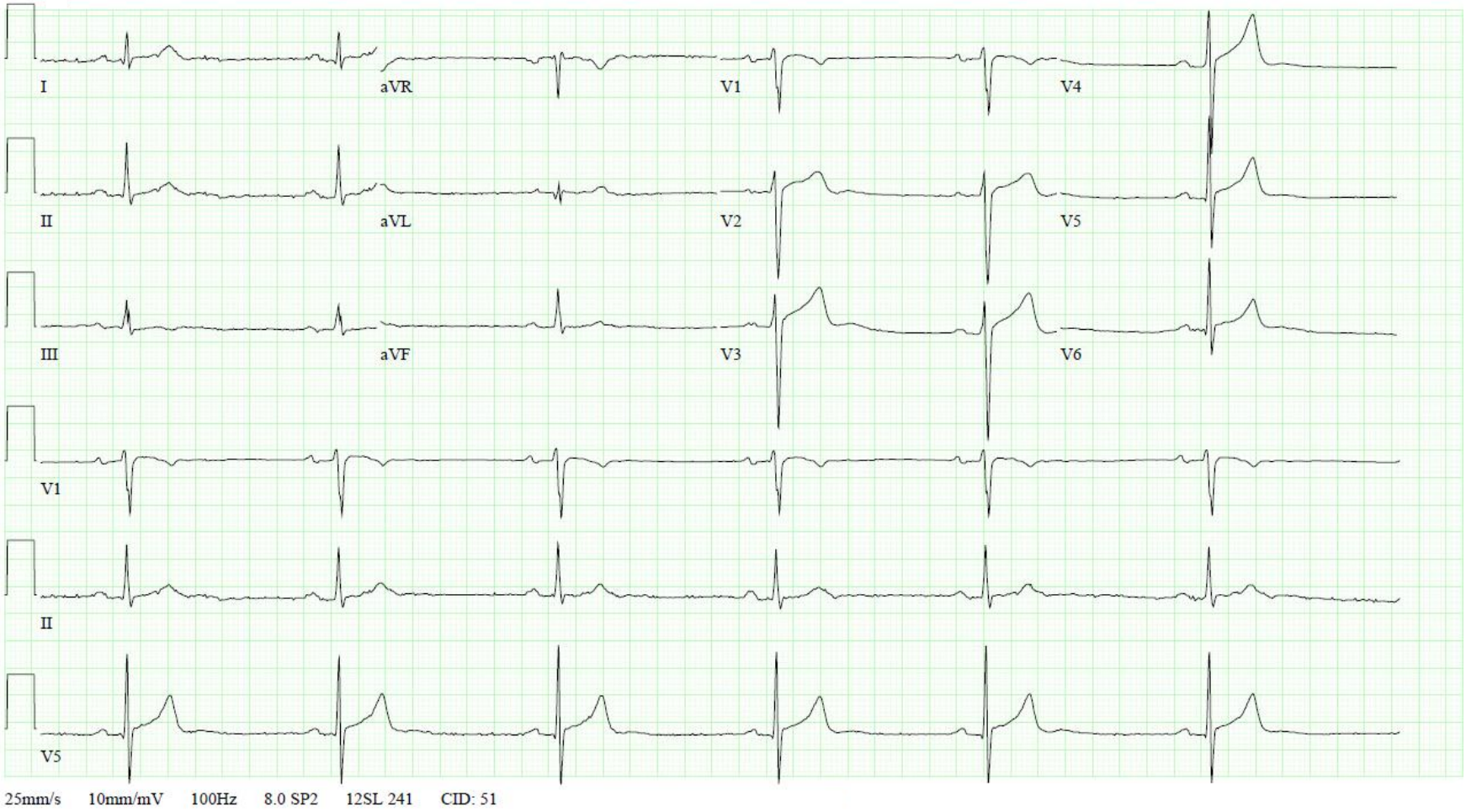
- 10-20% increase in LV wall thickness
- 10% increase in LV cavity dimension
- Biatrial enlargement – LA is on average 7ml/m2 or 4mm larger in athletes
- There is balanced enlargement of the RV
- Aorta is slightly larger in athletes but very rarely >4cm

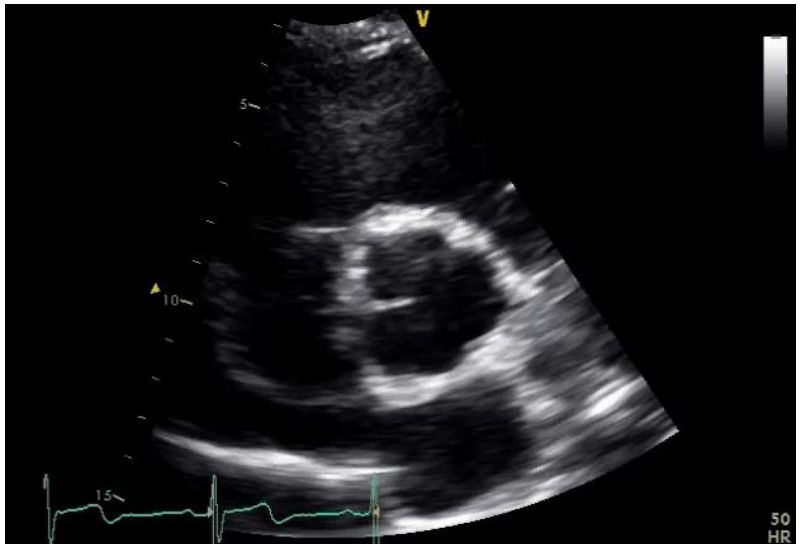


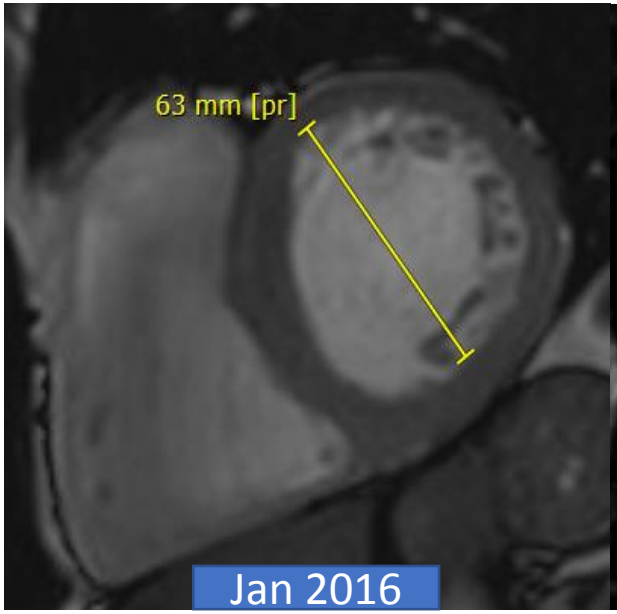
Factors Which Influence the Athlete's Heart

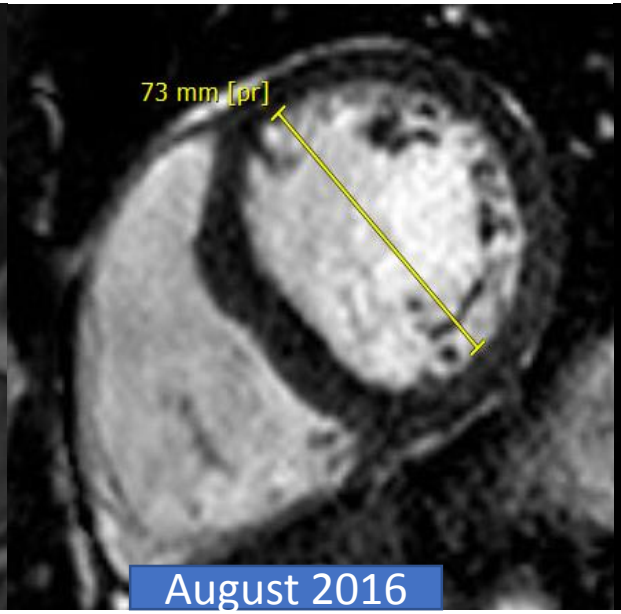


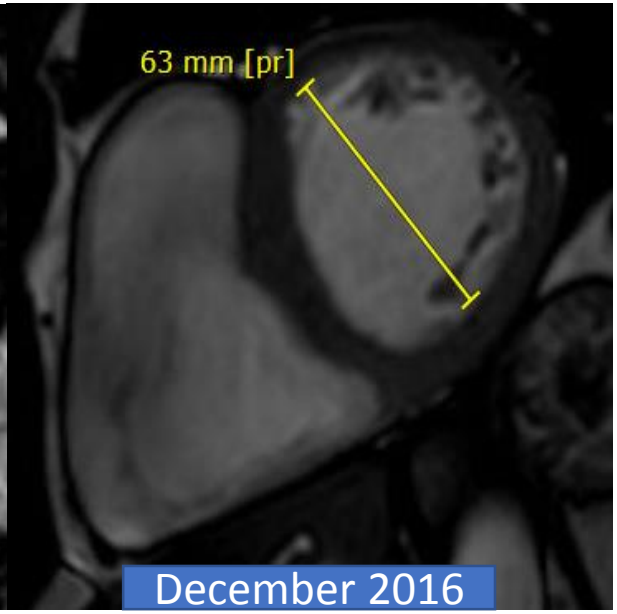
49 year old male Ironman presents with murmur

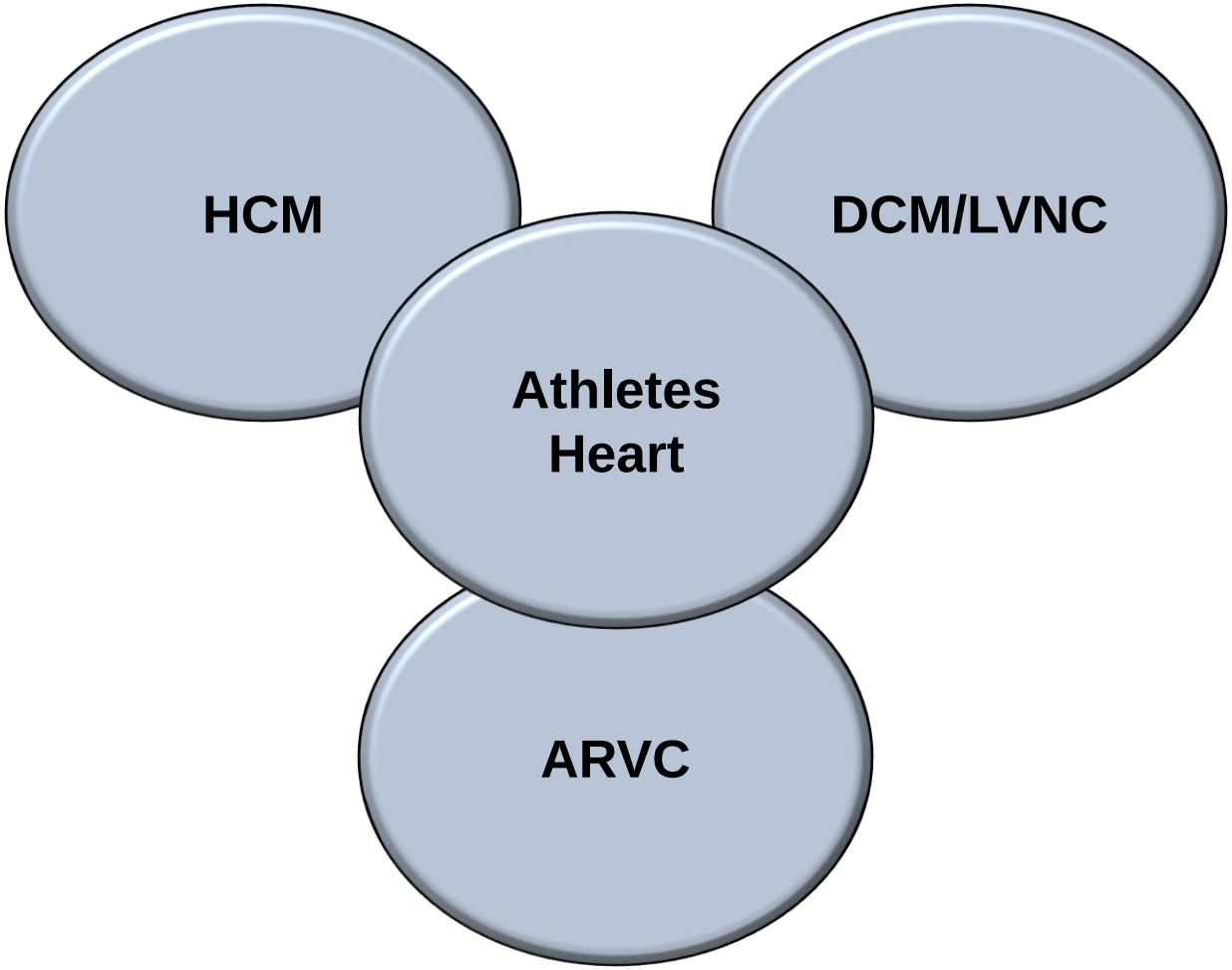




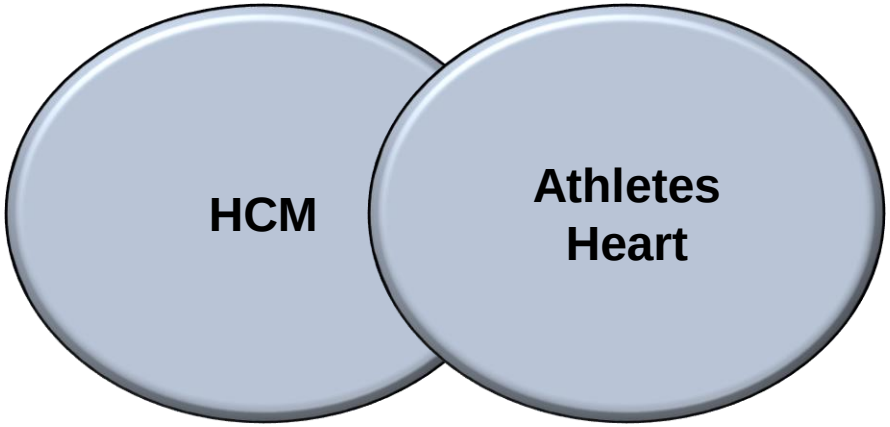

63 mm [pr]
Jan 2016

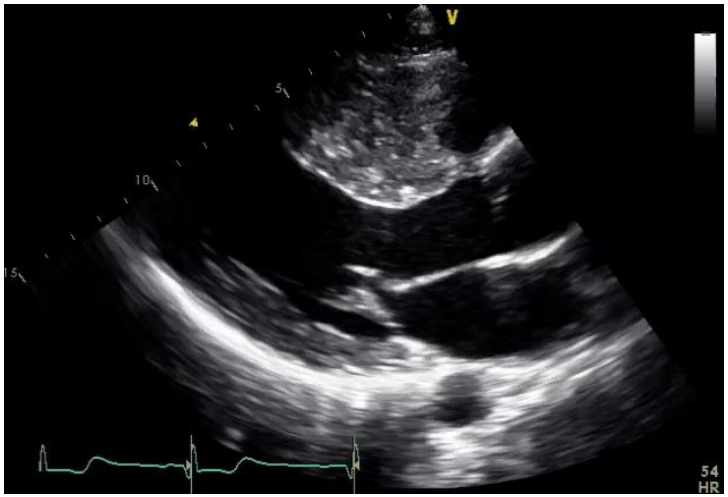

73 mm [pr]
August 2016


63 mm [pr]
December 2016


HCM
DCM/LVNC
Athletes Heart
ARVC

Left Ventricular Wall Thickening





How do I differentiate HCM from Athletes Heart in 2018?

Frequently Useful

- Distribution of hypertrophy
- Chamber size
- Chamber shape
- Mitral valve structure and function
- DGE on MRI
- Family history

Occasionally Useful

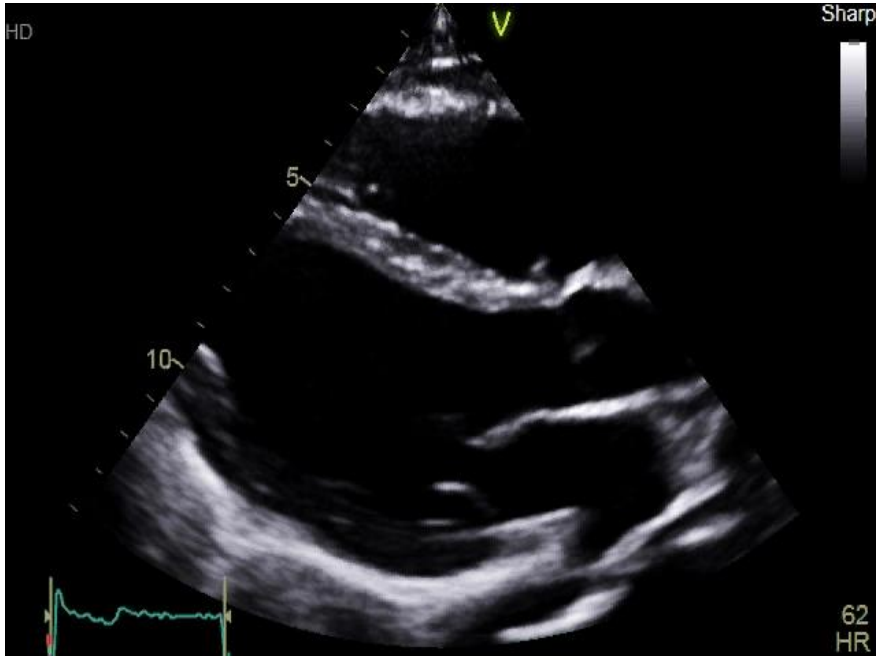
- Diastolic function
- Exercise capacity
- Strain Imaging
- Genetic testing
- Abnormal ECG

Rarely Useful

- LA size
- Deconditioning

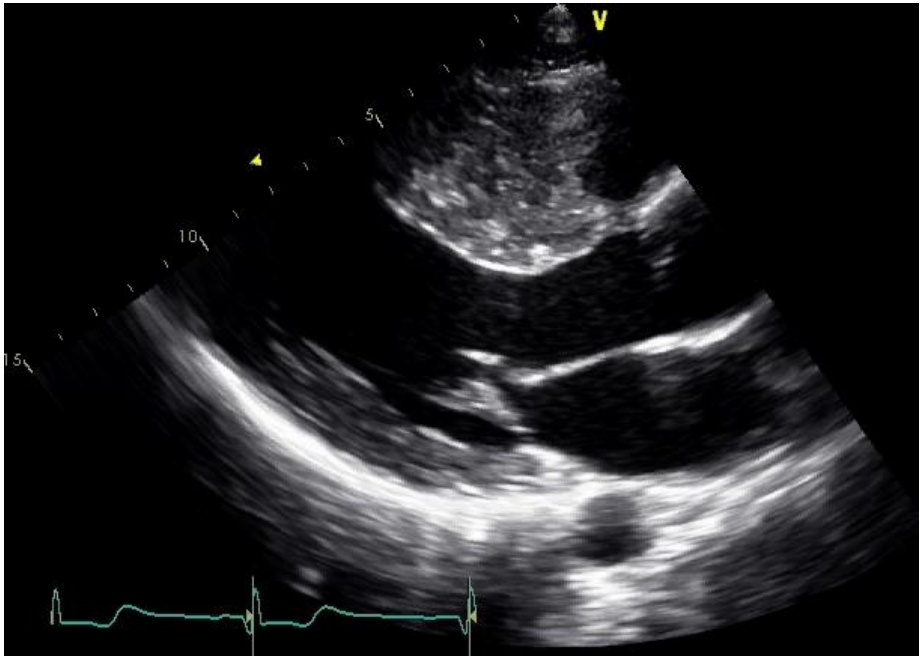
Chamber Size, Shape and Pattern of Hypertrophy

Athlete with Mild Eccentric LVH



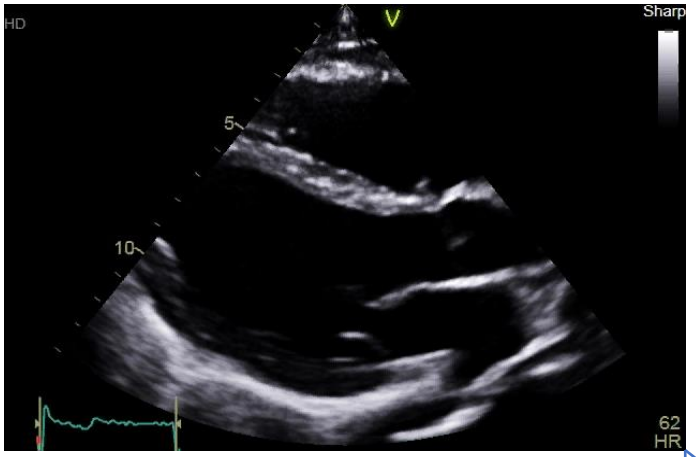
Chamber is frequently dilated in athletes
Uniform pattern of thickening

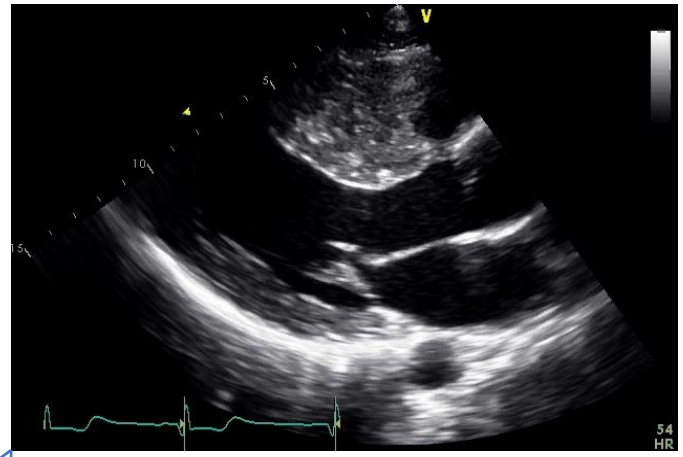
Athlete with HCM



Chamber is very rarely dilated in HCM
Asymmetric pattern of thickening

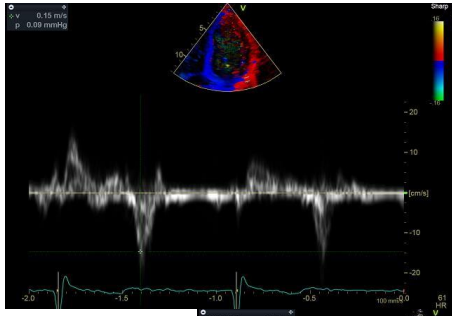
Diastolic Function



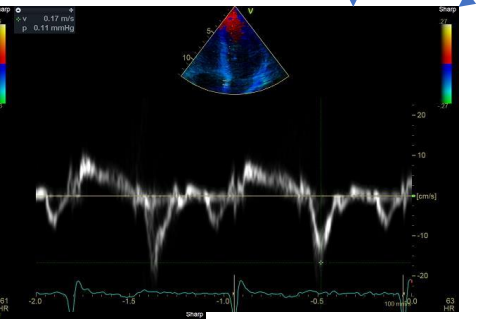


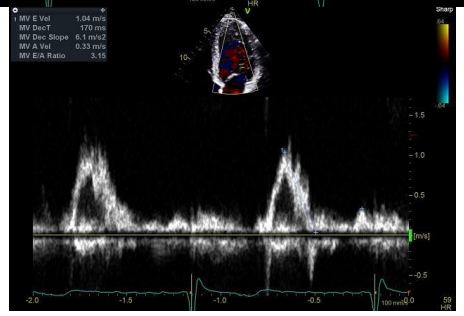
?

Lateral e' = 15m/s

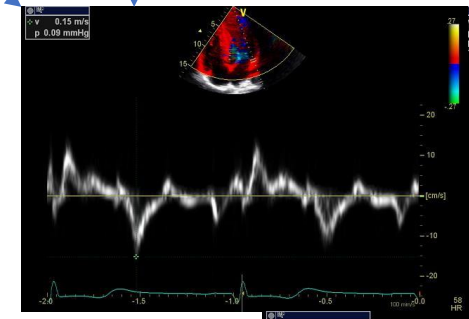


Medial e' = 12m/s

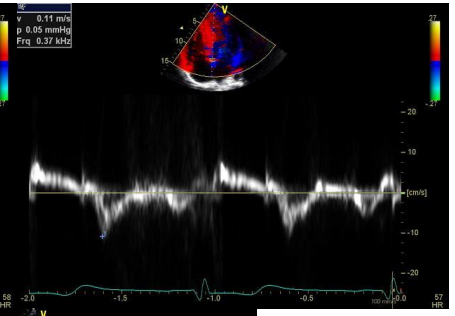


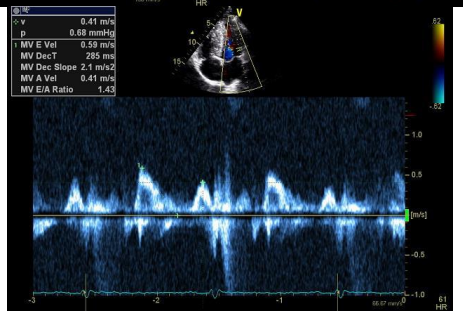


Lateral e' = 15m/s



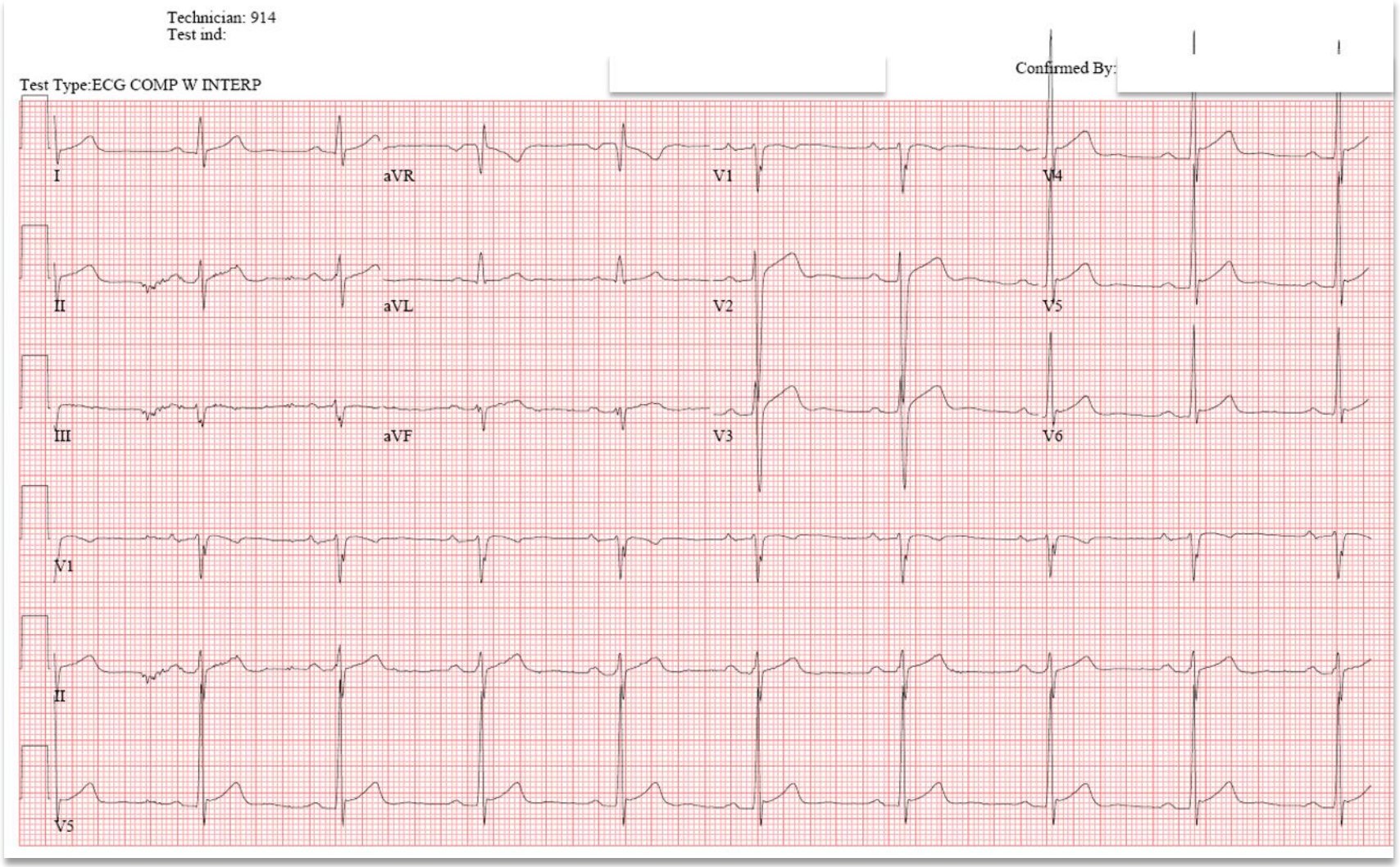
Medial e' = 11m/s

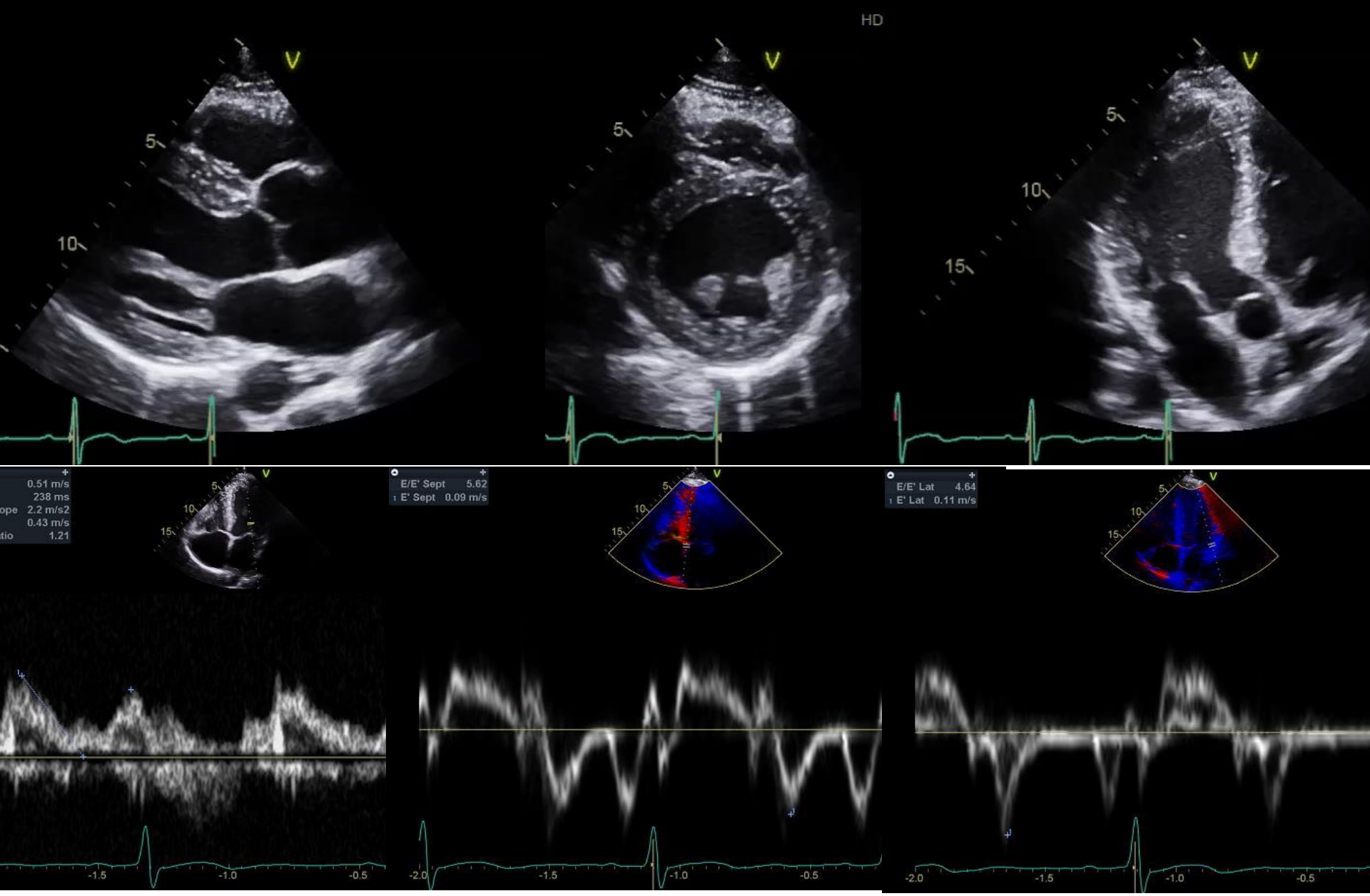




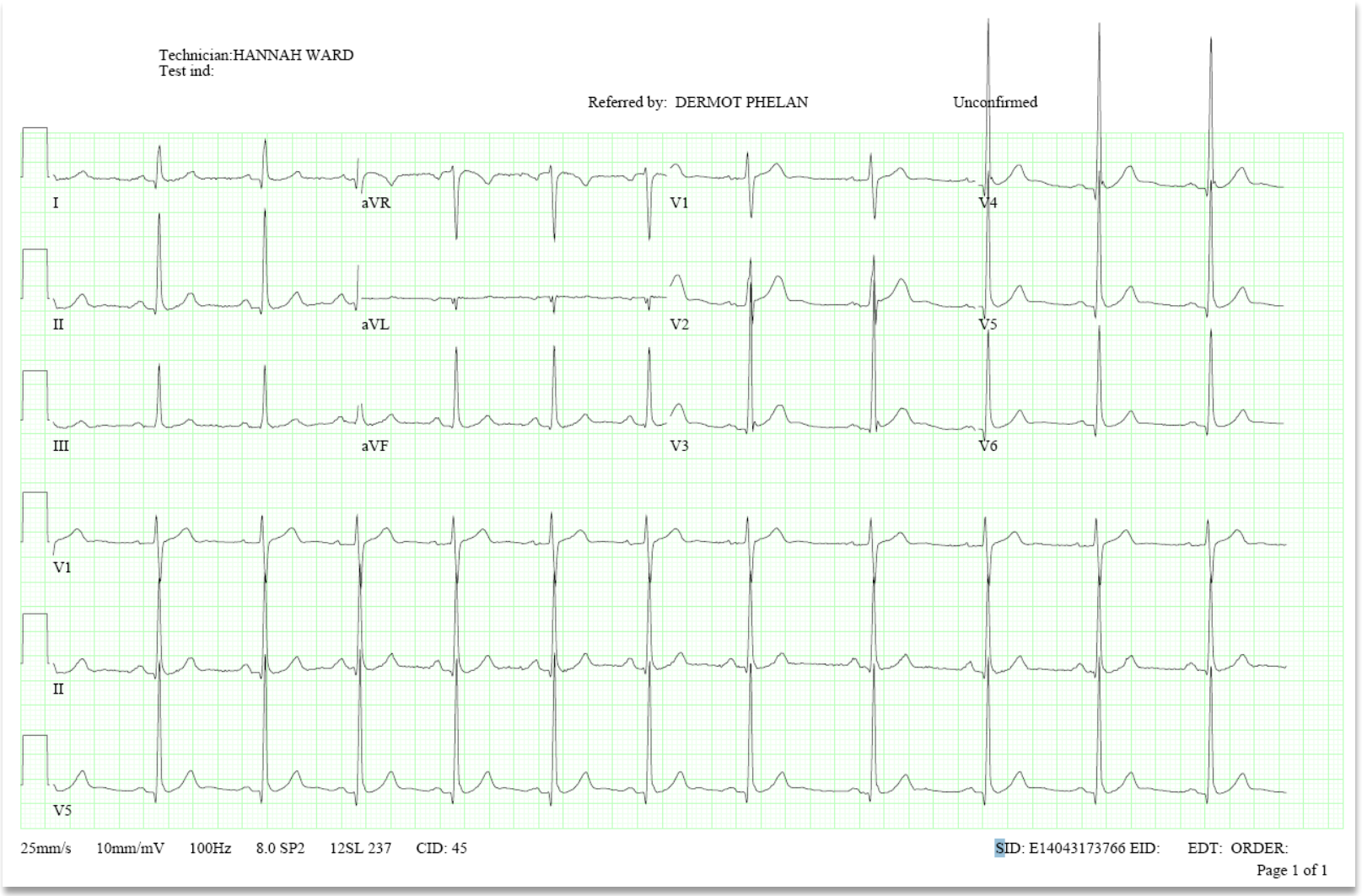
Which of the Following 2 Cases is an Athlete and Which as HCM?

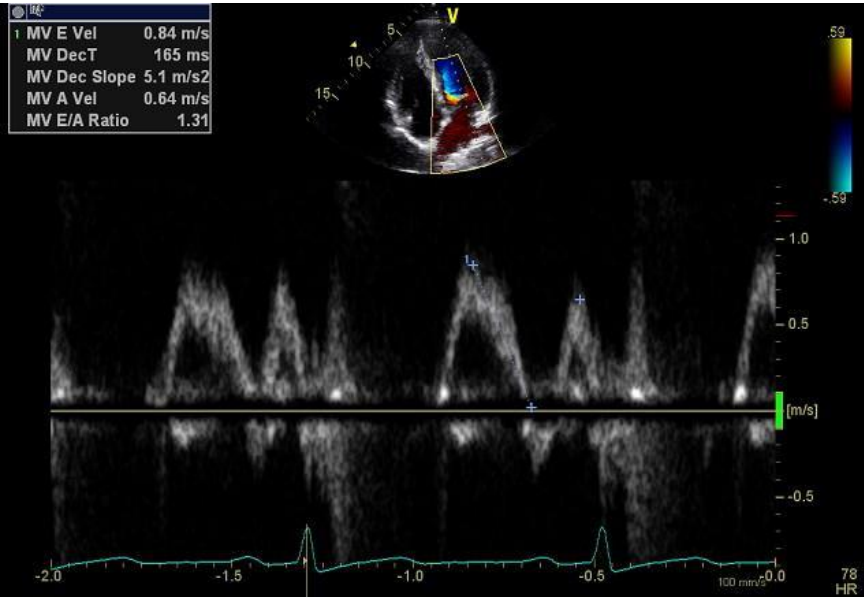
Case Number 1

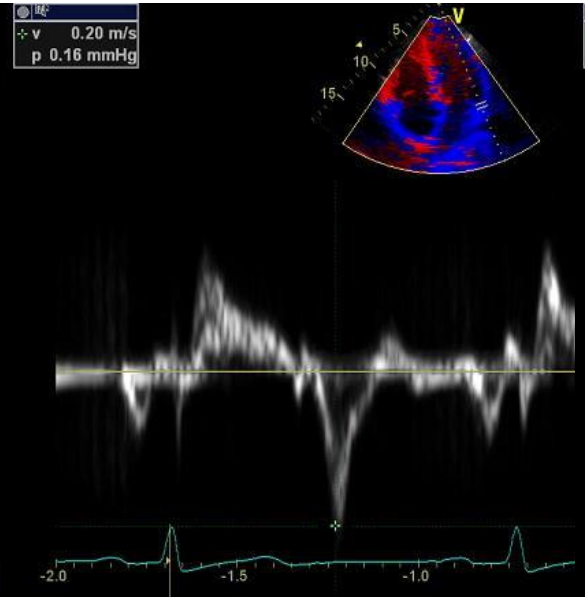


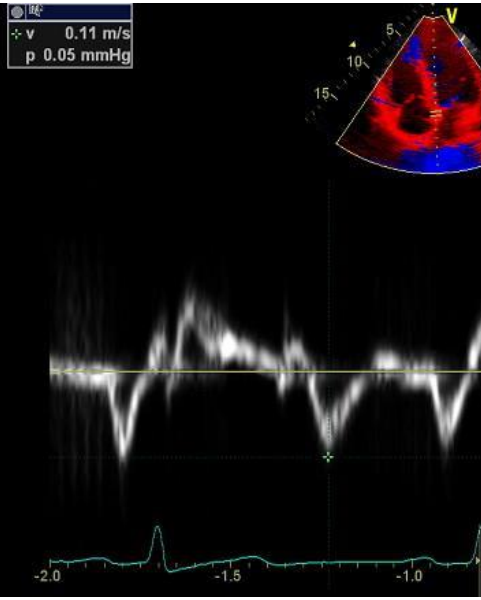

HD
E/E' Sept 5.62
E' Sept 0.09 m/s
E/E' Lat 4.64
E' Lat 0.11 m/s

Case Number 2

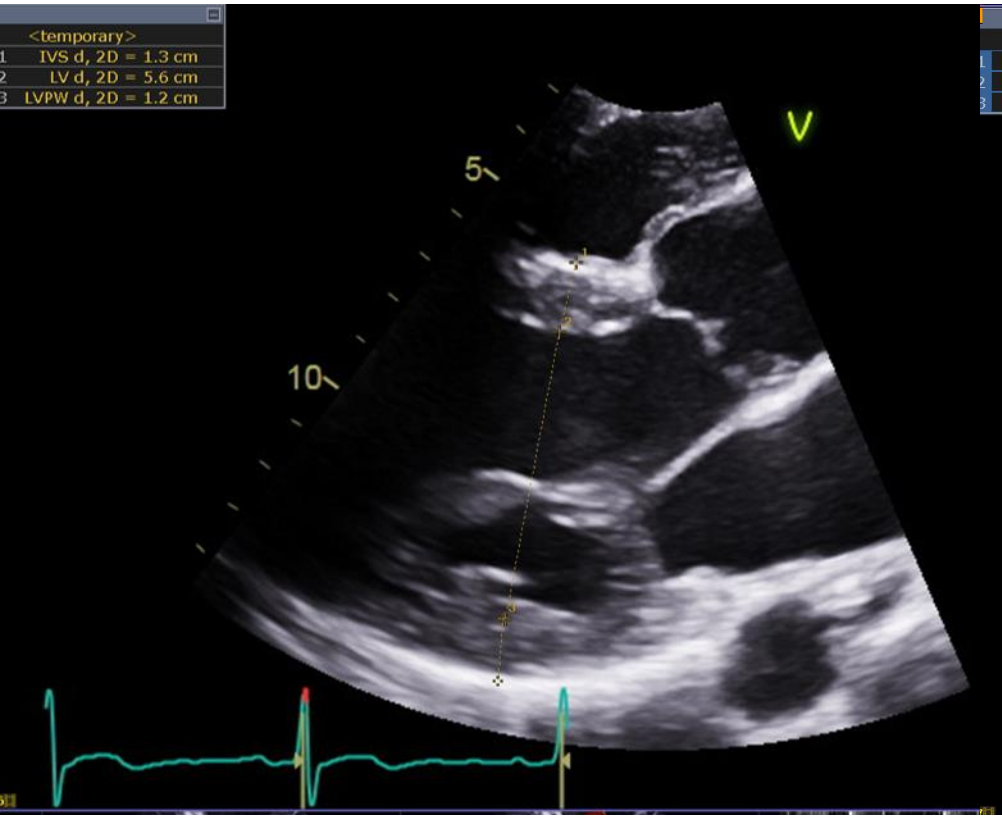



MV E Vel 0.84 m/s
MV DecT 165 ms
MV Dec Slope 5.1 m/s2
MV A Vel 0.64 m/s
MV E/A Ratio 1.31
1.0
0.5
[m/s]
-0.5
-2.0
-1.5
-1.0
-0.5
0.0
78
HR

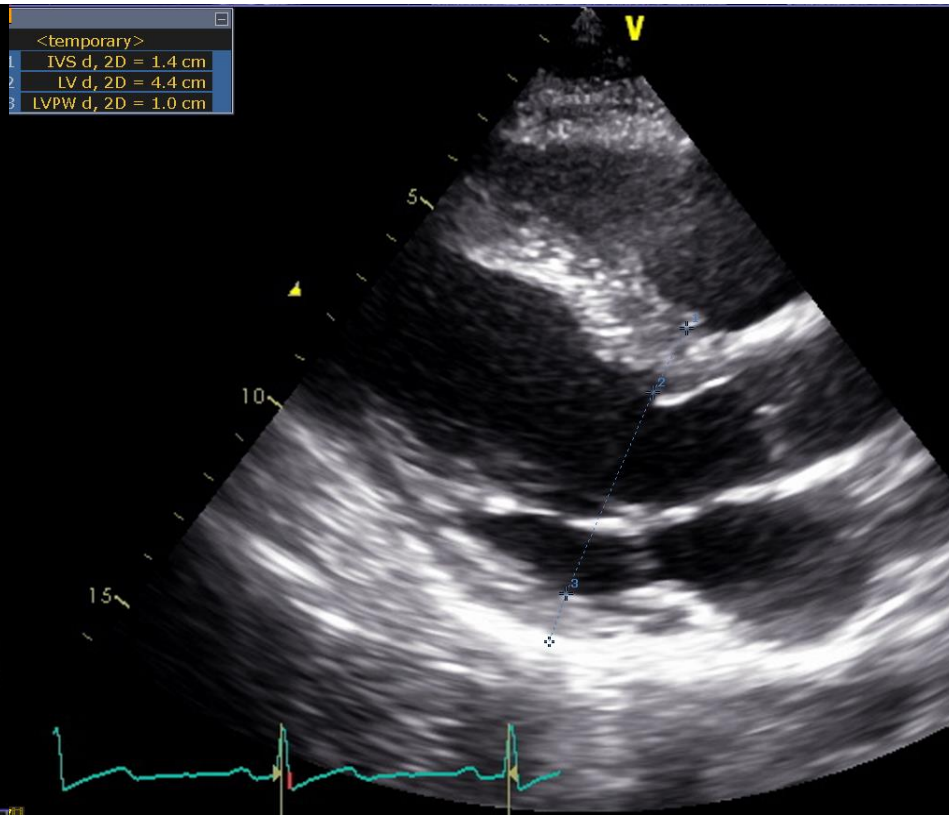

v 0.20 m/s
p 0.16 mmHg
-2.0
-1.5
-1.0


v 0.11 m/s
p 0.05 mmHg
-2.0
-1.5
-1.0

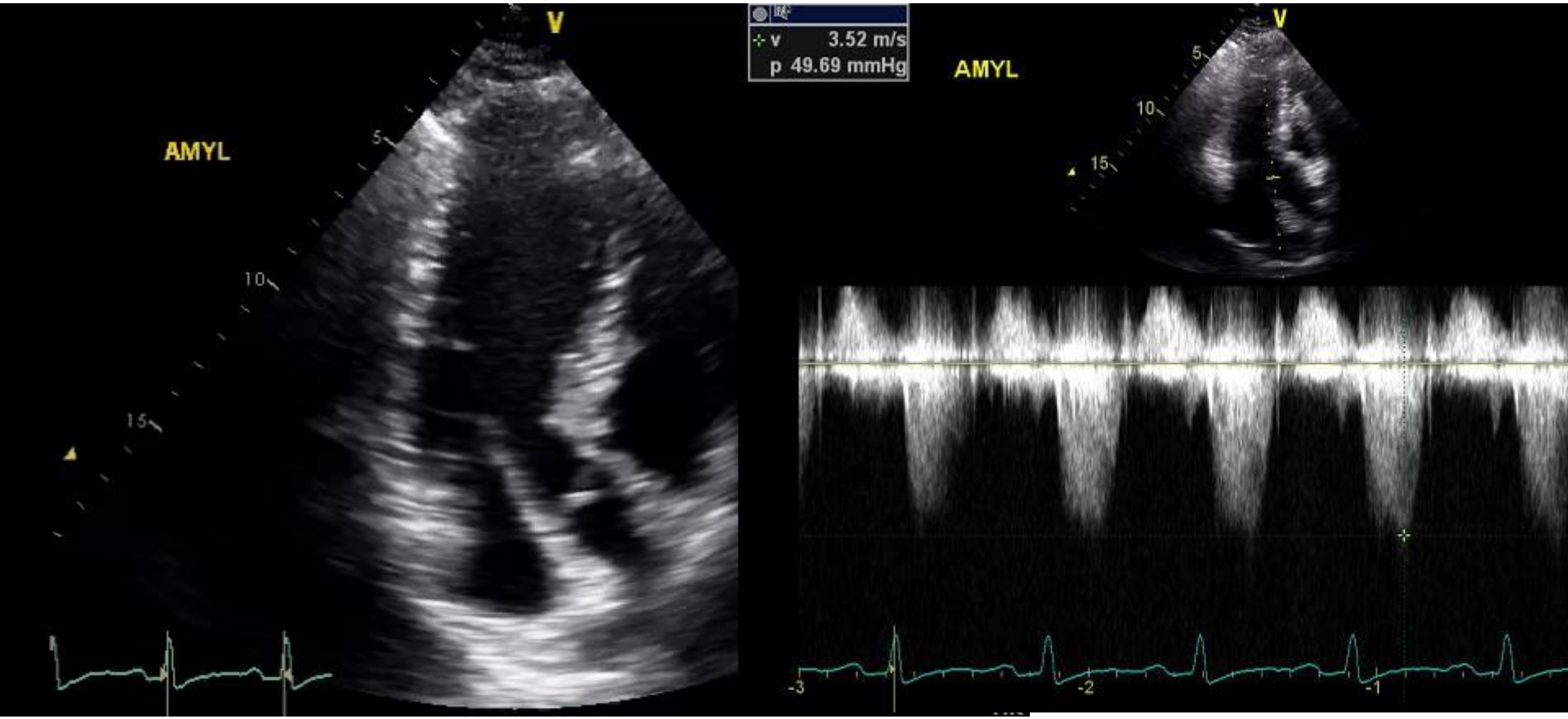
Case Number 1

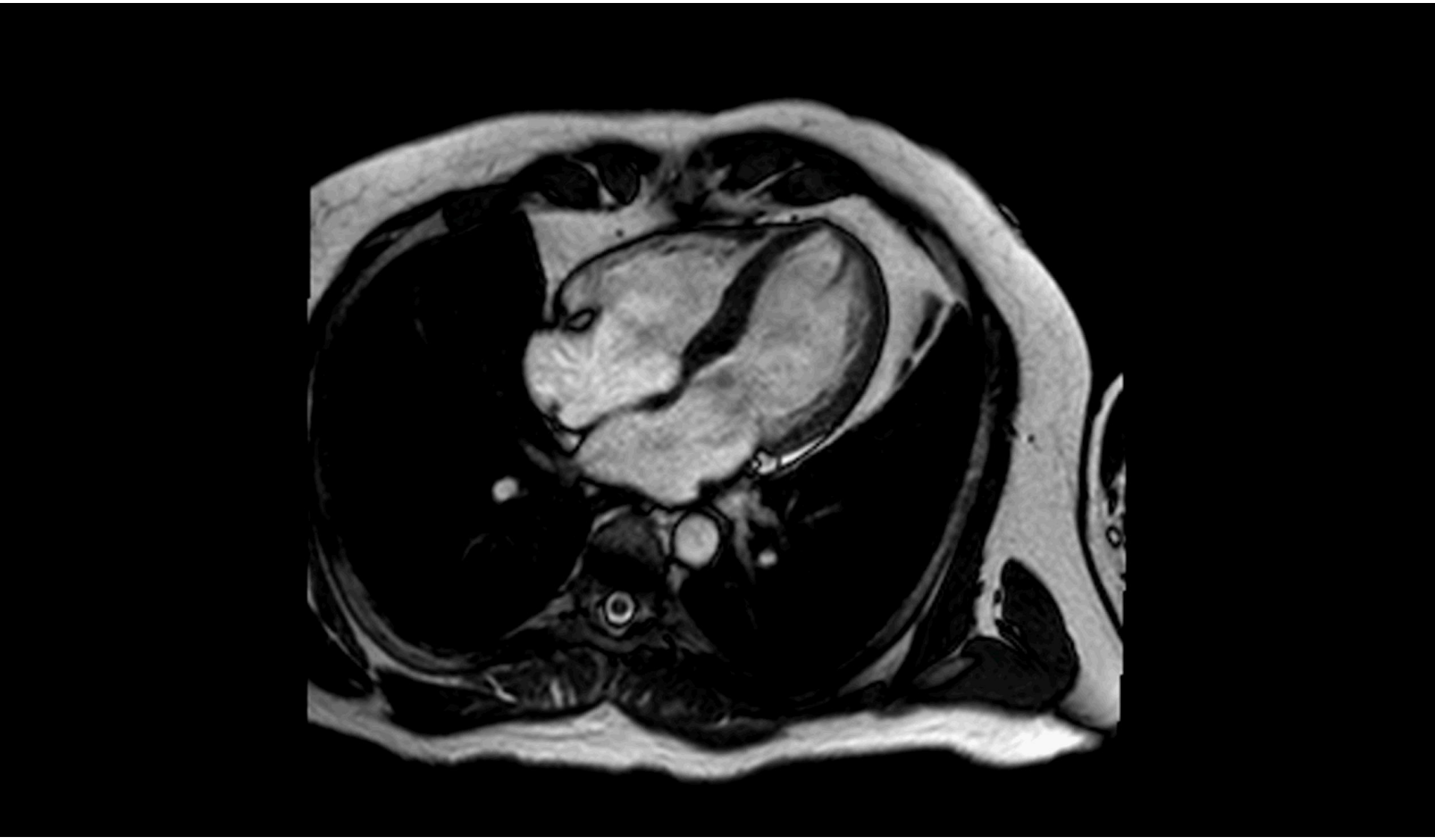


Case Number 2

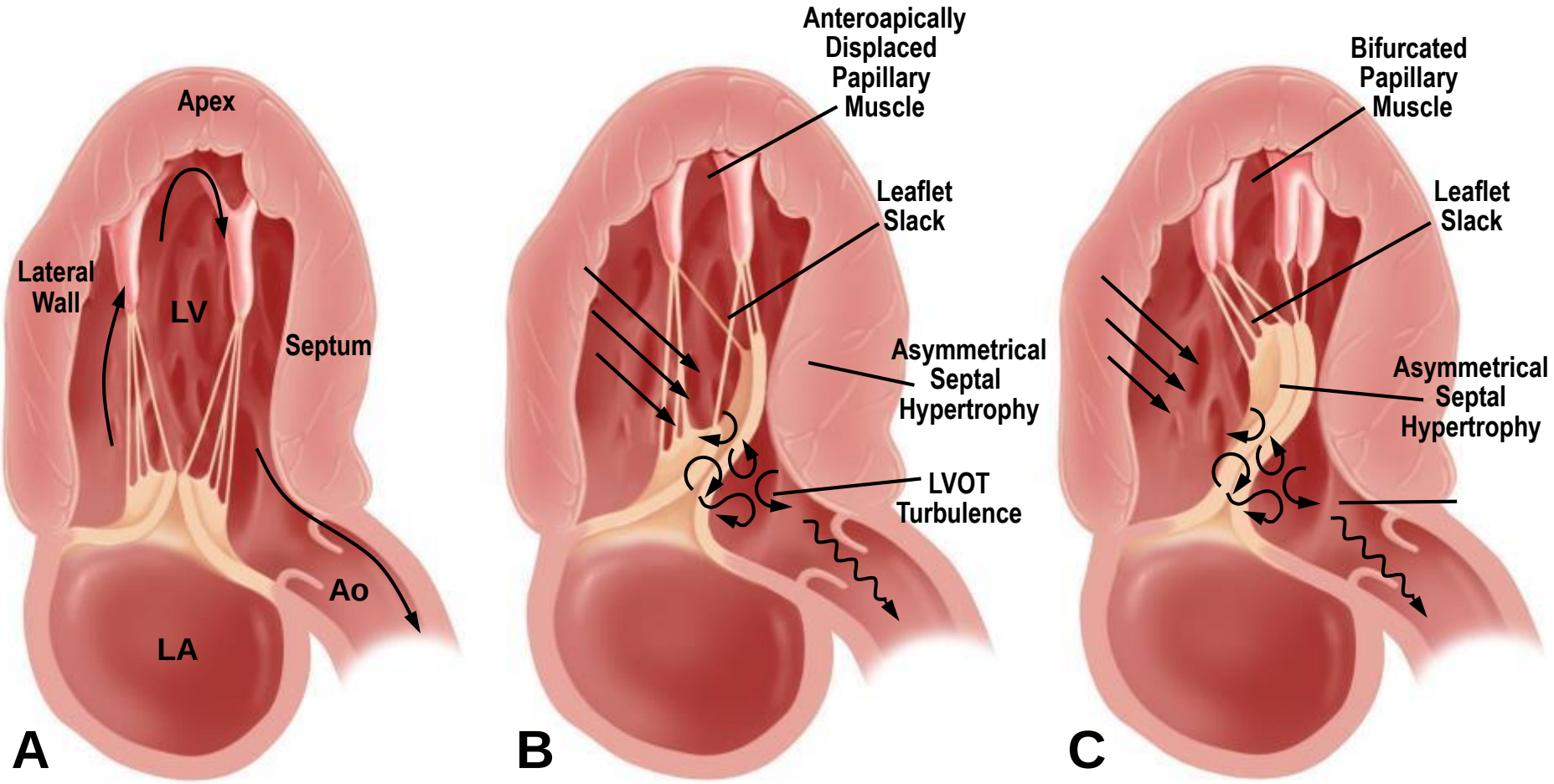


Case Number 2





Mitral Valve Morphology

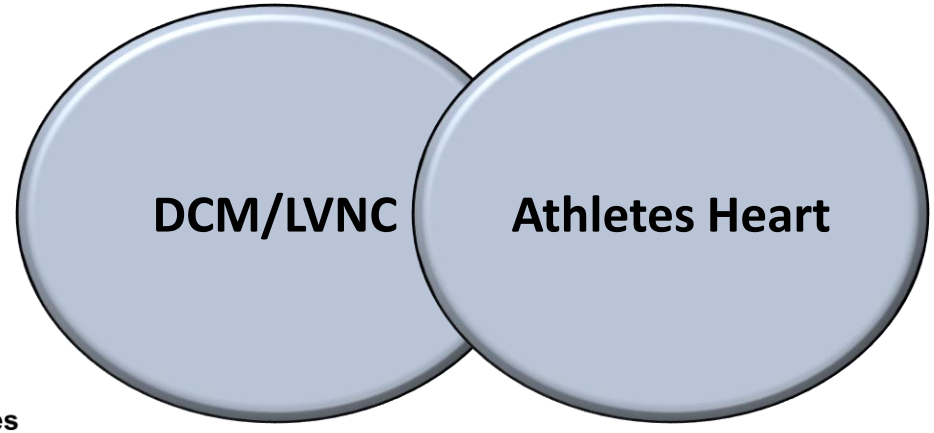


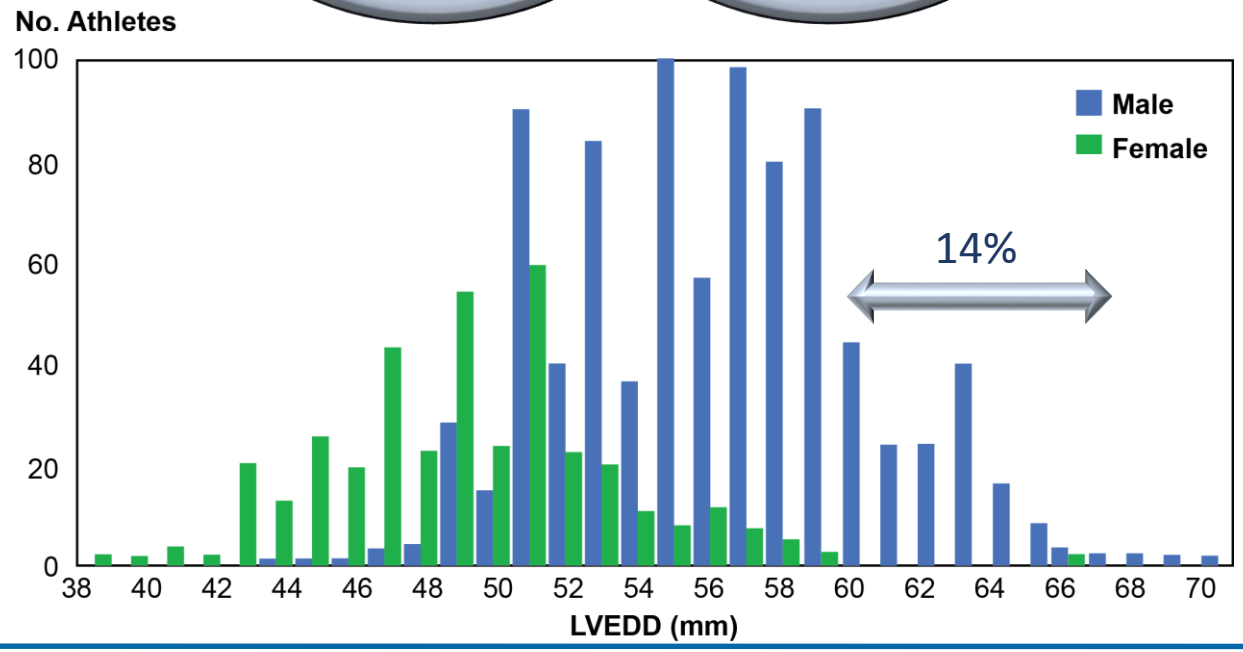
Kwon D H et. al. Heart

My 10 Step Approach to the Athlete in the Grey Zone with Increased Wall Thickness

1. What is the clinical presentation: family history of HCM, symptomatic, abnormal ECG, or was this discovered incidentally?
2. Is the LV wall thickened? Ensure not including RV trabeculation and good alignment – MRI can be helpful.
3. What is the pattern of thickness? Is there >2mm difference between contiguous segments or is it homogenous?
4. What is the LV dimension?
5. Is the wall thickness/LV dimension appropriate for that athlete (consider sport type/race/sex/age/size)?
6. Is the mitral valve normal is structure and function?
7. Is there DGE on MRI?
8. Is the exercise capacity consistent that individual athlete?
9. Review diastolic function and strain
10. Usually the answer is within – rarely is genetic testing/detraining necessary.

Left Ventricular Dilation





Distribution of LVEF and LV dimensions in 286 Tour de France cyclists

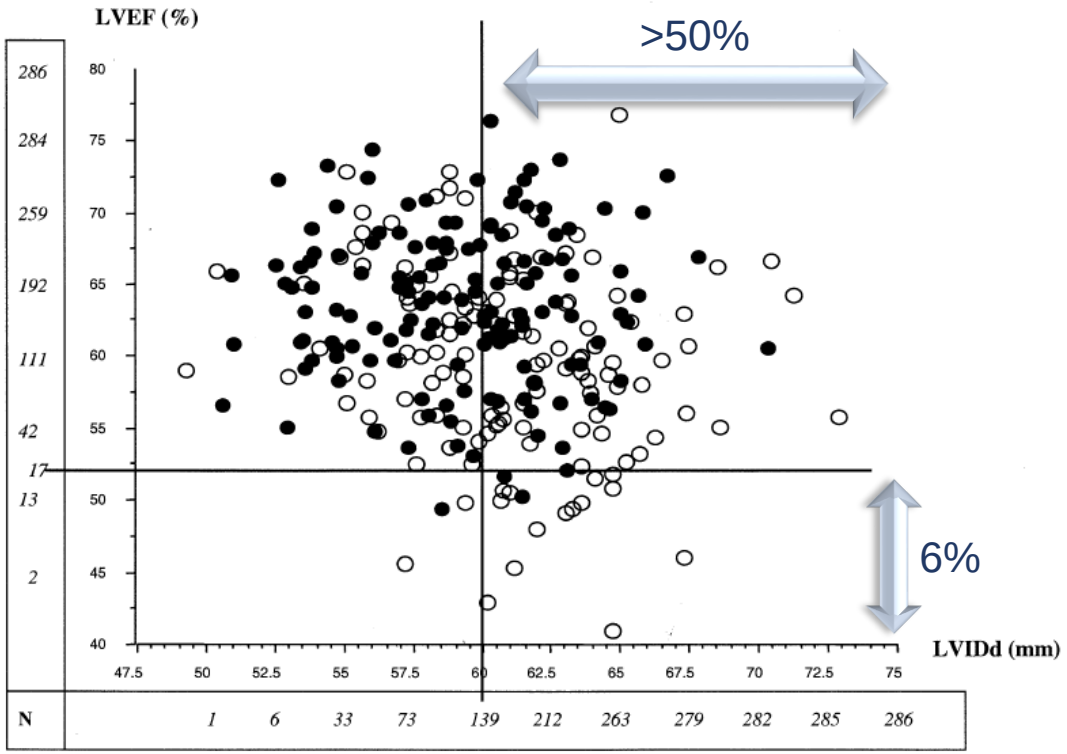


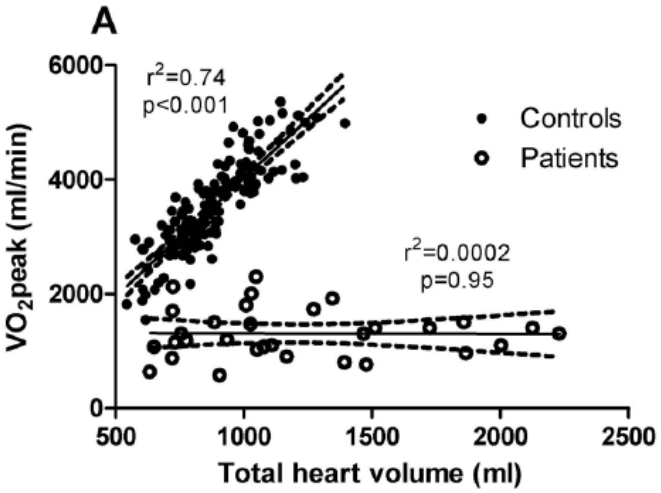
Figure 1. Plot of left ventricular ejection fraction (LVEF) against left ventricular internal diameter at end diastole (LVIDd) in all cyclists (**solid circles** = 1995; **open circles** = 1998). The **solid vertical bar** represents the normality threshold (60 mm) for LVIDd, and the **solid horizontal bar** represents the normality threshold (52%) for LVEF. Numbers in **italics** in front of each axis value are cumulative numbers of cyclists with a value below the corresponding axis value.

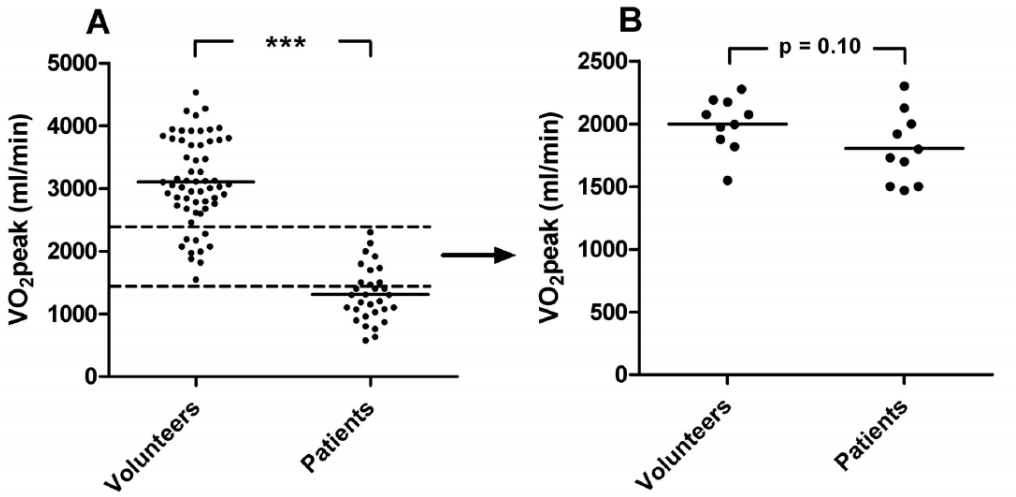
Abergel et. al. JACC 2004

Journal of Cardiovascular Magnetic Resonance

RESEARCH Open Access

Peak oxygen uptake in relation to total heart volume discriminates heart failure patients from healthy volunteers and athletes



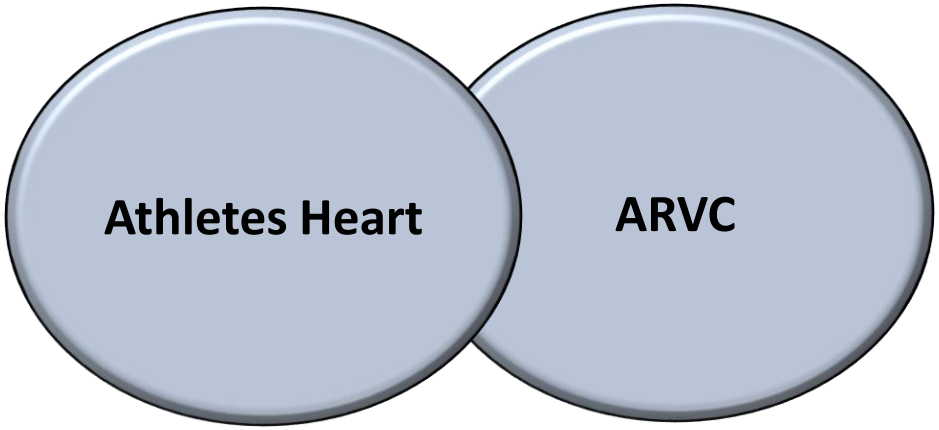


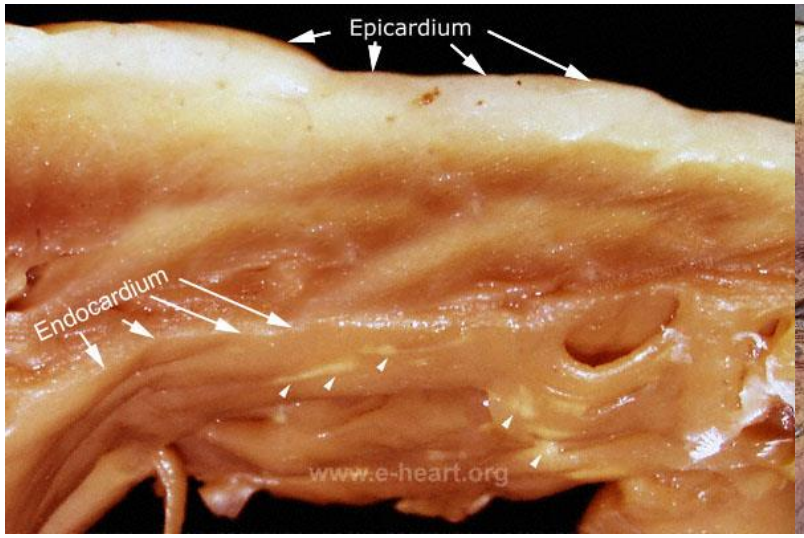
Engblom et. al. JCMR 2010

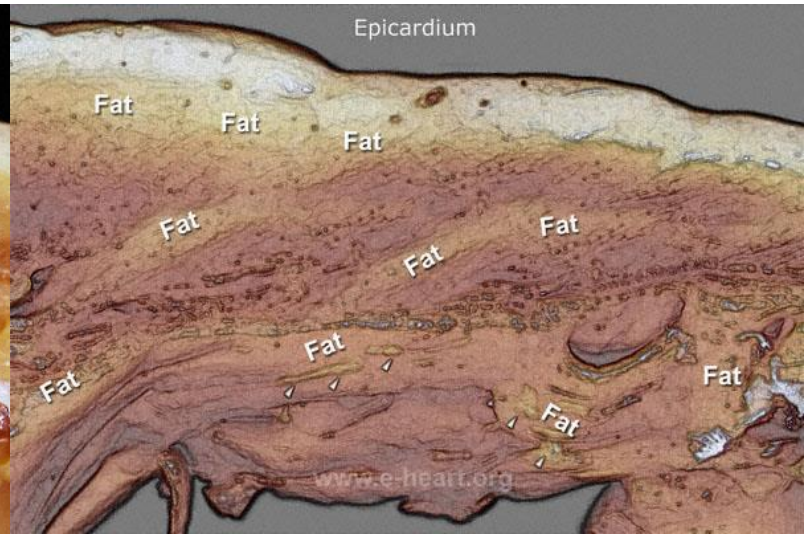
My Approach to the Athlete in the "Gray Zone".

- Generally, LV dilation is not isolated in athletes heart accompanied by eccentric LVH, RV and LA dilation
- Diastolic function and strain should be normal.
- Exercise testing is useful
  - LV augments normally
  - Should have supranormal exercise capacity

Right Ventricular Dilation







2010 revised Task Force criteria for the diagnosis of Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC)

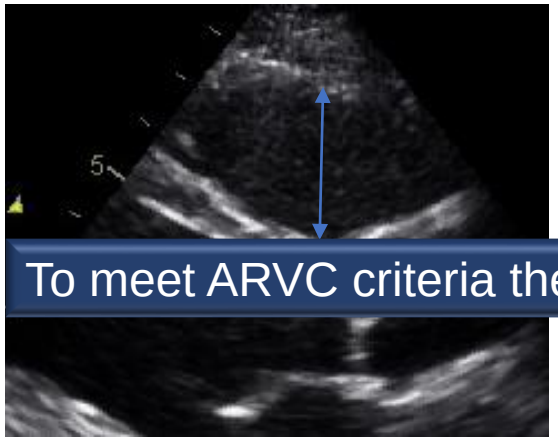
	Revised Task Force criteria
I. Global or regional dysfunction and structural alterations*	
Major	**By 2D echo:** • Regional RV akinesia, dyskinesia, or aneurysm • *and* 1 of the following (end diastole): - PLAX RVOT ≥32 mm (corrected for body size [PLAX/BSA] ≥19 mm/m^2) - PSAX RVOT ≥36 mm (corrected for body size [PSAX/BSA] ≥21 mm/m^2) - *or* fractional area change ≤33 percent
	By MRI: • Regional RV akinesia or dyskinesia or dyssynchronous RV contraction • *and* 1 of the following: - Ratio of RV end-diastolic volume to BSA ≥110 mL/m^2 (male) or ≥100 mL/m^2 (female) - *or* RV ejection fraction ≤40 percent
	By RV angiography: • Regional RV akinesia, dyskinesia, or aneurysm
Minor	**By 2D echo:** • Regional RV akinesia or dyskinesia • *and* 1 of the following (end diastole): - PLAX RVOT ≥29 to <32 mm (corrected for body size [PLAX/BSA] ≥16 to <19 mm/m^2) - PSAX RVOT ≥32 to <36 mm (corrected for body size [PSAX/BSA] ≥18 to <21 mm/m^2) - *or* fractional area change >33 percent to ≤40 percent
	By MRI: • Regional RV akinesia or dyskinesia or dyssynchronous RV contraction • *and* 1 of the following: - Ratio of RV end-diastolic volume to BSA ≥100 to <110 mL/m^2 (male) or ≥90 to <100 mL/m^2 (female) - *or* RV ejection fraction >40 percent to ≤45 percent

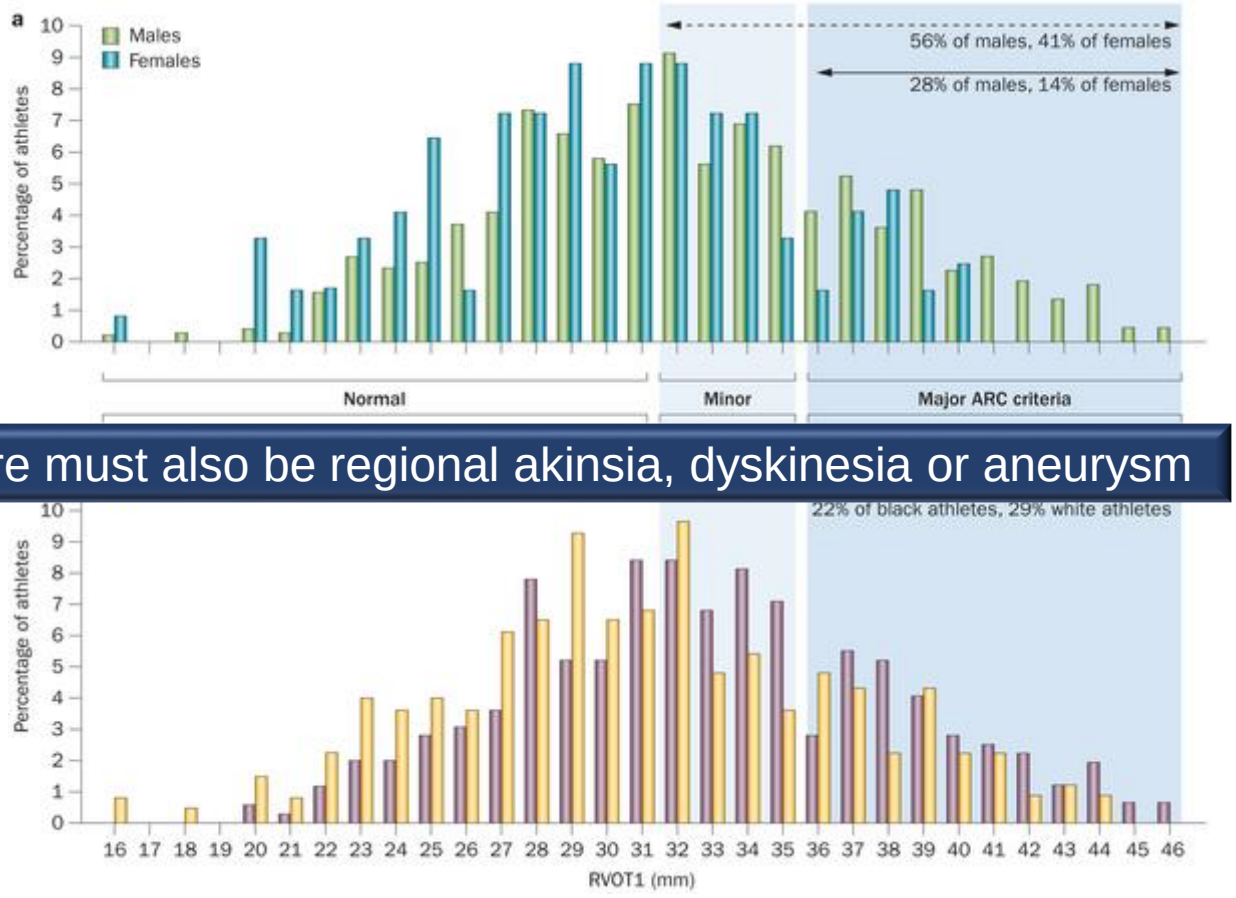
	• ARVC/D confirmed pathologically at autopsy or surgery in a first-degree relative • Identification of a pathogenic mutationΔ categorized as associated or probably associated with ARVC/D in the patient under evaluation
Minor	• History of ARVC/D in a first-degree relative in whom it is not possible or practical to determine whether the family member meets current Task Force criteria • Premature sudden death (<35 years of age) due to suspected ARVC/D in a first-degree relative • ARVC/D confirmed pathologically or by current Task Force Criteria in second-degree relative

Diagnostic terminology for revised criteria:

- Definite diagnosis: 2 Major, OR 1 Major and 2 Minor criteria, OR 4 Minor from different categories
- Borderline diagnosis: 1 Major and 1 Minor, OR 3 Minor criteria from different categories
- Possible diagnosis: 1 Major, OR 2 Minor criteria from different categories

Right Ventricular Dimensions in Highly Trained Athletes





To meet ARVC criteria there must also be regional akinsia, dyskinesia or aneurysm

Zaidi et al Circulation 2013

My Approach to the Athlete in the "Gray Zone".

- In endurance athletes the RV is commonly dilated.
- Associated with LV dilation
- MRI is helpful to assess for regional dyskinesia/akinesis and aneurysm.
- Response to exercise and long term monitor may be necessary

Care of the Athletic Heart:
A comprehensive Sports Cardiology Program.

Pre-participation screening

Exercise induced cardiac remodeling vs cardiac pathology

Discuss risk of extreme exercise

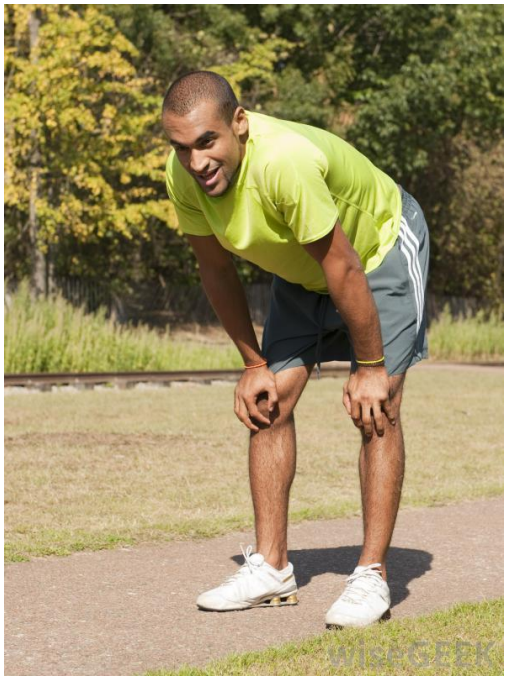
Evaluate the symptomatic athlete

Manage athletes with CV disease

Evaluating the symptomatic athlete

Chest Pain

Short of Breath



Collapse/syncope

Palpitations

Performance decrement

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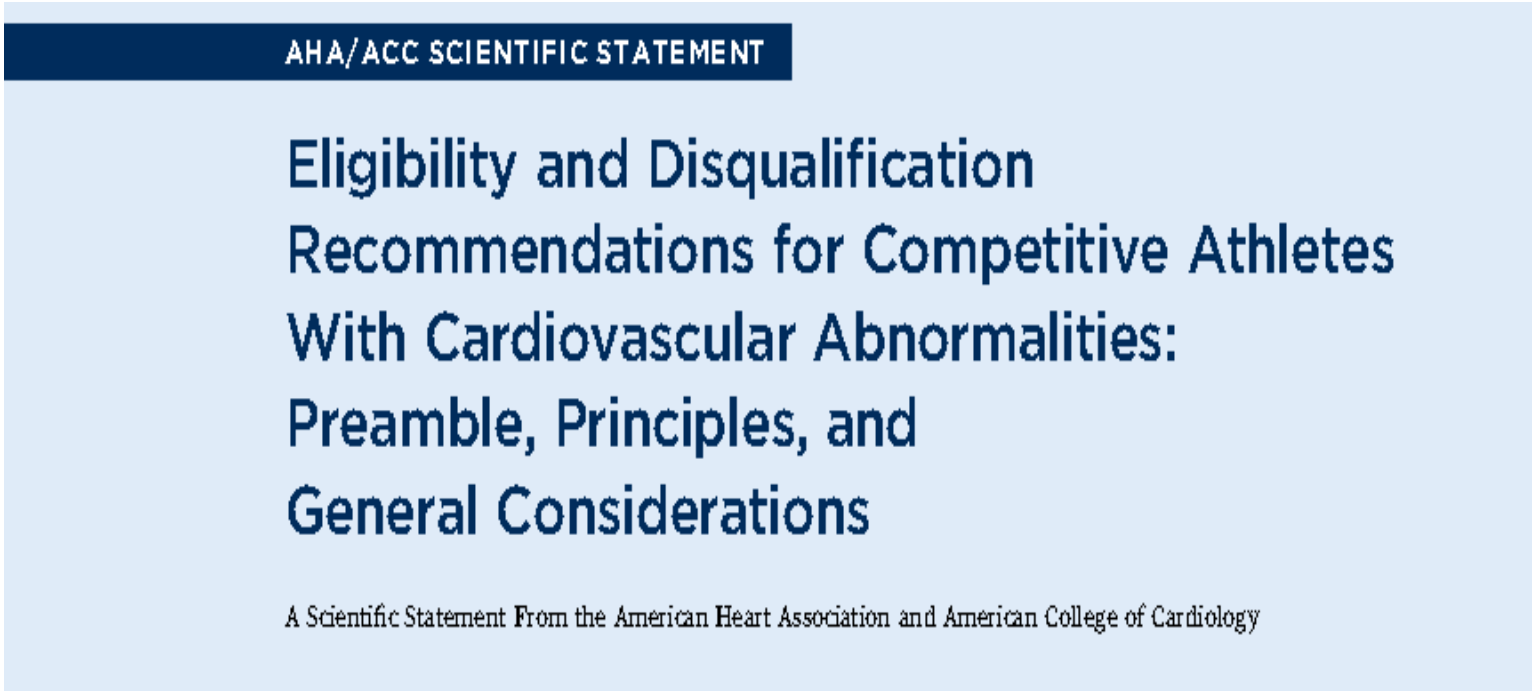
Management of the Athlete with CV Disease

- Listen and respect their athletic ambitions.
- Use best practice guidelines for underlying condition wherever possible.
- Try to use medications that won't interfere with performance – so long as they are equally efficacious.
- Ensure medications are permissible by the governing sporting body – apply for exemptions if necessary.
- Use a shared decision making model for sporting participation.



- No of recommendations in the document: 241

  - Level of evidence A: 3 (1%)
  - Level of evidence B: 46 (19%)
  - Level of evidence C: 192 (80%)

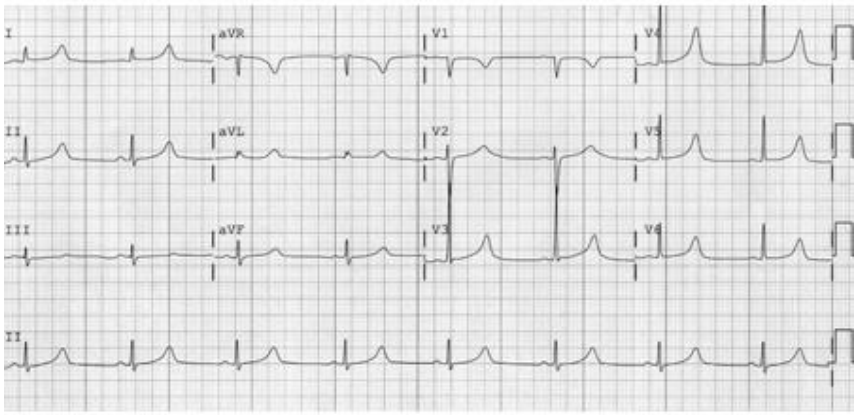
Changing Guidelines and Recognizing Limitations.

Sports participation with ICD

Safety of Sports for Athletes With Implantable Cardioverter-Defibrillators

Results of a Prospective, Multinational Registry

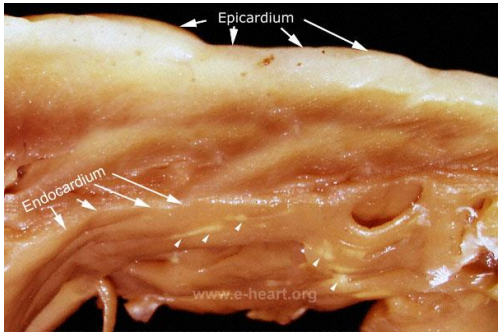
Sports participation with Long QT

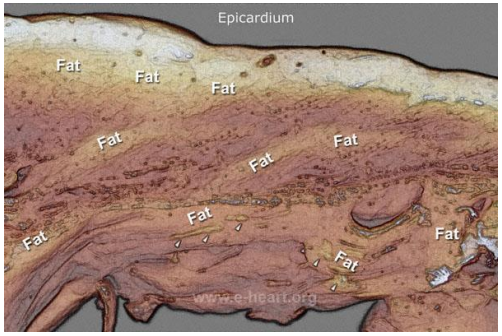


Sports Participation in Genotype Positive Children With Long QT Syndrome

Peter F. Aziz, MD,* Tammy Sweeten, MS,† Ramon L. Vogel, MD,† William J. Bonney, MD,† Jacqueline Henderson, RN,† Akash R. Patel, MD,‡ Maully J. Shah, MBBS†

Changing Guidelines and Recognizing Limitations.





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ISSN 0735 1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2013.06.033

Heart Rhythm Disorders

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

Baltimore, Maryland

- Symptoms develop at an earlier age in athletes (~30 vs 40 years)
- Athletes have a lower lifetime survival free of VT/VF than non-athletes.

Interassociation consensus statement on cardiovascular care of college student-athletes

- "The ACC/AHA provides recommendations for safe participation in athletes with cardiovascular conditions that **can be used as an initial guideline**.
- A model that uses a **comprehensive evaluation**, **extensive patient/family counselling**, and **prudent medical management for risk reduction and informed decision-making that involves all key stakeholders in the oversight of the athlete** (eg, coaches, athletic trainers, team physicians and athletic directors) provides a sensible strategy to structure difficult cardiac clearance decisions."

Hainline B et al BMJ/JACC 2016

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Exercise at the Extremes

Biomarkers of Cardiac Stress and Injury in Athletes: What Do They Mean?

Eoin Donnellan [1] · Dermot Phelan [1]

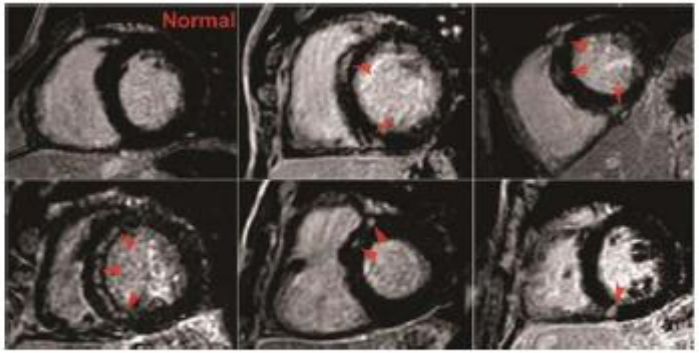

Figure 3 Delayed gadolinium enhancement in five athletes. Images of five athletes in whom focal delayed gadolinium enhancement (DGE) was identified in the interventricular septum (indicated with arrows) when compared with an athlete with a normal study (top left).

ORIGINAL RESEARCH ARTICLE

Prevalence of Subclinical Coronary Artery Disease in Masters Endurance Athletes With a Low Atherosclerotic Risk Profile

Europace (2009) 11, 1156–1159
doi:10.1093/europace/eup197

CLINICAL RESEARCH
Atrial Fibrillation

Is the risk of atrial fibrillation higher in athletes than in the general population? A systematic review and meta-analysis

Jawdat Abdulla* and Jens Rokkedal Nielsen

European Heart Journal (2012) 33, 998–1006
doi:10.1093/eurheartj/ehr397

CLINICAL RESEARCH
Exercise

Exercise-induced right ventricular dysfunction and structural remodelling in endurance athletes

André La Gerche[1,2]*, Andrew T. Burns[3], Don J. Mooney[3], Warrick J. Inder[1], Andrew J. Taylor[4], Jan Bogaert[5], Andrew I. MacIsaac[3], Hein Heidbüchel[2], and David L. Prior[1,3]

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Thank you for your attention
Cleveland Clinic
Sydell & Arnold Miller Family Pavilion