

Morte Improvvisa nel Giovane Atleta

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First Author	Year	Country	Case Identification	SCD/SCA	Years Studied	Annual Incidence	Number of Years	Age Range, y	Number of Deaths
Van Camp et al ¹¹³	1995	United States	National Center for Catastrophic Injury Research and media database	SCD	1983-1993	0.3:100,000	10	17-24	160
Corrado et al ²⁵	2003	Italy	Mandatory death reporting	SCD	1979-1999	2.3:100,000	20	12-35	55
Maron et al ²	2009	United States	USA Registry for Sudden death in Athletes	SCA + SCD	1980-2006	0.6:100,000	27	8-39	690
Drezner et al ¹⁰²	2009	United States	1,710 high schools with AEDs surveyed for SCA or SCD	SCA + SCD	2006-2007	4:100,000 SCA + SCD 2.2:100,000 SCD	Within months of survey	14-17	14
Harmon et al ¹¹⁴	2011	United States	Parent Heat Watch database, NCAA Resolutions list, insurance claims	SCD	2004-2006	2.3:100,000	4	18-26	37
Marijon et al ¹¹⁵	2011	France	Emergency medical response to confirmed cardiac cases	SCA + SCD	2005-2010	1:100,000	5	12-75	820
Steinvil et al ¹⁰⁰	2011	Israel	Retrospective review (2 Israeli newspapers by 2 media researchers)	SCD	1985-2005	1st 2.5:100,000 2nd 2.6:100,000	24	12-44	24
Roberts et al ¹¹	2013	United States	Minnesota State High School League records	SCD	1993-2012	0.24:100,000	19	12-19	4
Maron et al ¹¹⁶	2013	United States	USA Registry for Sudden Death in Athletes and NCAA resolutions list for cardiac cases	SCD	2002-2013	1.6:100,000 presumed 1.2:100,000 confirmed	9	17-26	64
Maron et al ⁹⁹	2013	United States	USA Registry of Sudden Death in Athletes	SCD	1986-2011	0.6:100,000	26	12-18	13
Toresdahl et al ¹¹⁷	2014	United States	2,149 school students—events occurred on school campus	SCA + SCD	2009-2011	1.1:100,000	2	14-18	18 SCA 2 SCD
Harmon et al ³	2015	United States	NCAA database	SCD	2003-2013	1.9:100,000	10	17-24	79
Marijon et al ¹¹⁸	2015	United States	Population the Oregon-Sudden Unexpected Death Study (Oregon-SUDS)	SCA	2002-2013	2.2:100,000 (during sports activities)	11	35-65	1,247 SCA cases, 63 SCA during sports activities
Malhotra et al ¹²	2018	United Kingdom	Football association registry	SCD	1996-2016	6.8:100,000	20	16	8
Peterson et al ¹⁴	2021	United States	National Center for Catastrophic Sports Injury Research in collaboration with national sports organizations	SCD + SCA	2014-2018	1.5:100,000 (high school) 1.9:100,000 (NCAA level)	4	11-29	331 SCA, 173 SCD

Extreme variability

Numbers ranging between:

0.24:100,000 athletes/yr

6.8:100,000 athletes/yr

Finocchiaro et al. JACC 2024



Health Journal / By Krista Halicki and Kathryn Kinschold

Case Grows for Screening Young Athletes For Dangerous Heart Conditions

A 17-YEAR-OLD BASKETBALL player named a series of heart and blood vessel conditions that caused his sudden death.

The player, who died in 2003, was the first adolescent athlete diagnosed with a condition that is treatable with knowledge of signs and other symptoms.

The condition was typically detected after an on-screening test, or ECG, that is done before some sports activities.

The player's death was a tragedy, but it also was a warning that the condition is not as rare as once thought.

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But, he says, the player's death was a tragedy, but it also was a warning that the condition is not as rare as once thought.

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Sudden death not only in high profile professional athletes!



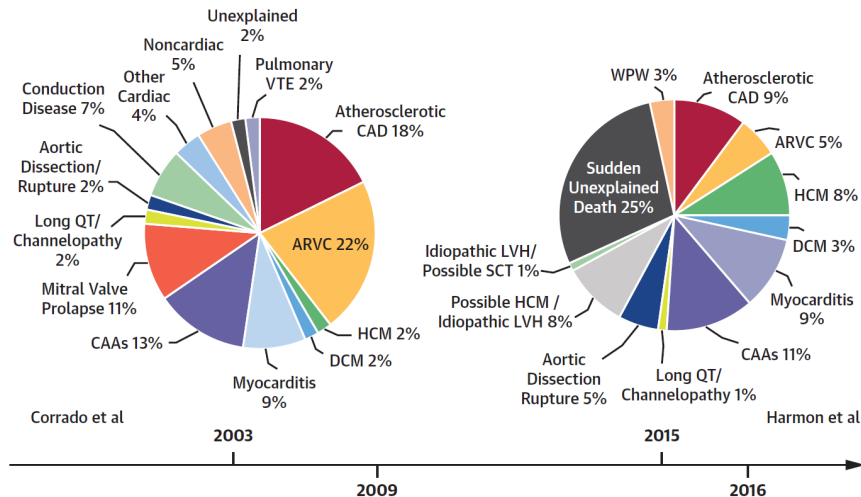
11 TRAGIC CASES OF ATHLETES WITH BAD TICKERS



Most Sudden Deaths in Adolescent Athletes Caused by Cardiac Conditions

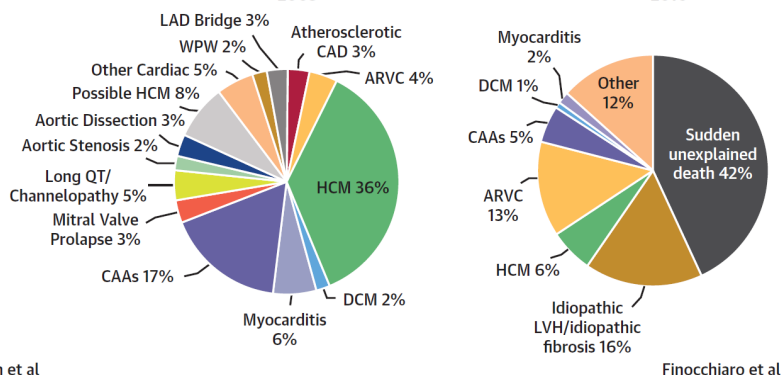
By Krista Halicki and Kathryn Kinschold





Extreme variability

Different methodology
Different cohorts

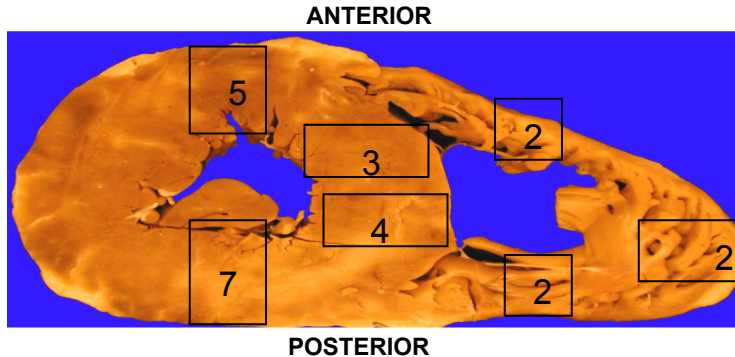


Finocchiaro, et al. JACC 2024



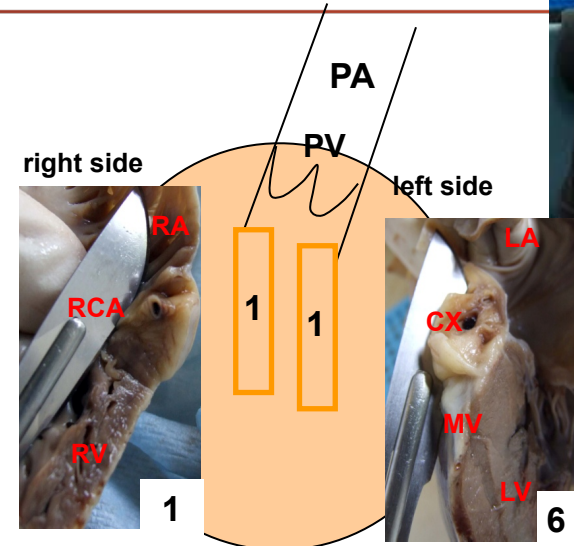


▼ Mid-ventricular slice between AV junction and apex



KEY: Blocks

- 1
 - Right ventricular outflow tract (RVOT) (x2)
 - RA & RCA & tricuspid valve leaflet & RV (x1)
- 2 Anterior, lateral, posterior RV (x3)
- 3 IVS anterior (x1)
- 4 IVS posterior (x1)
- 5 Anterior LV and LAD (x2)
- 6 LA & CX & Mitral valve leaflet & Lateral LV (x1)
- 7 Posterior LV and aorta (x2)
- 8 SA node (x2 - x4)
- 9 AV node (x2)
- 10 AV node (x2)



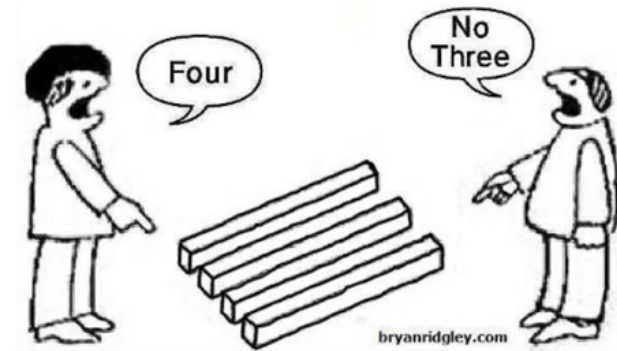
CX: circumflex, MV: mitral valve, LA: left atrium, LV: left ventricle, PA: pulmonary artery, PV: pulmonary valve, RCA: right coronary artery, RA: right atrium, RV: right ventricle

10 blocks of tissue



The importance of specialist cardiac histopathological examination in the investigation of young sudden cardiac deaths

Sofia V. de Noronha¹, Elijah R. Behr², Michael Papadakis², Keiko Ohta-Ogo³, Winston Banya³, Jemma Wells¹, Steve Cox⁴, Alison Cox⁴, Sanjay Sharma² and Mary N. Sheppard^{1,3*}

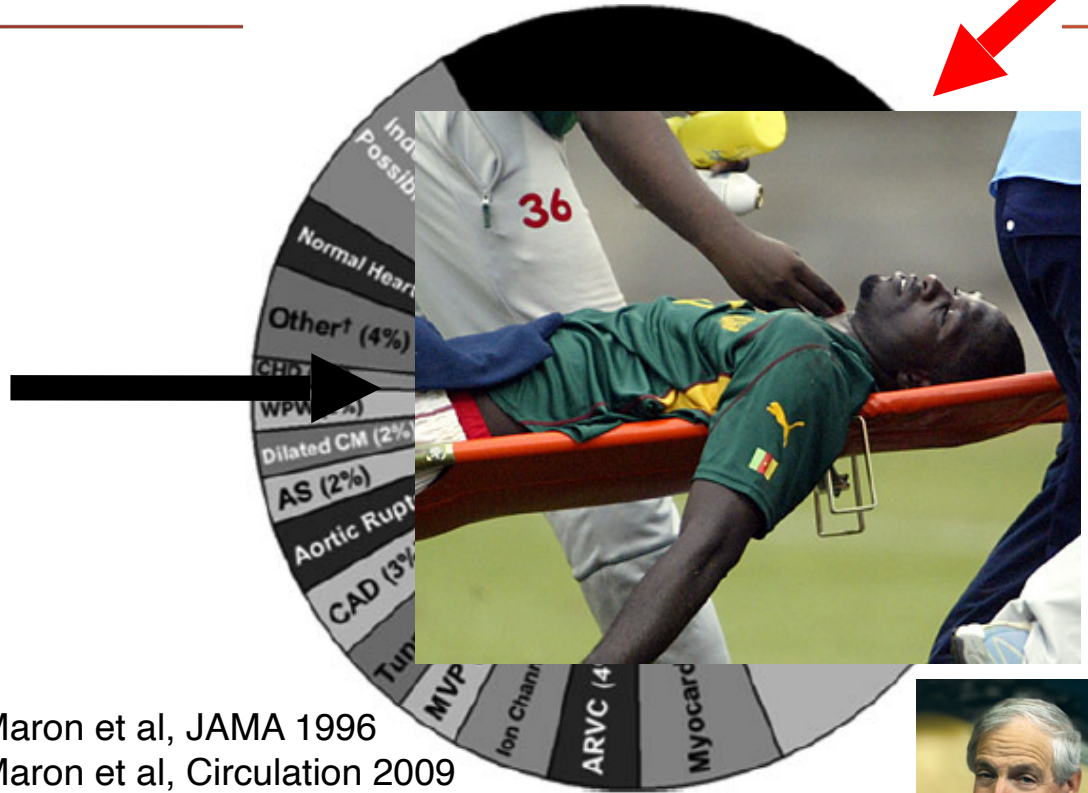
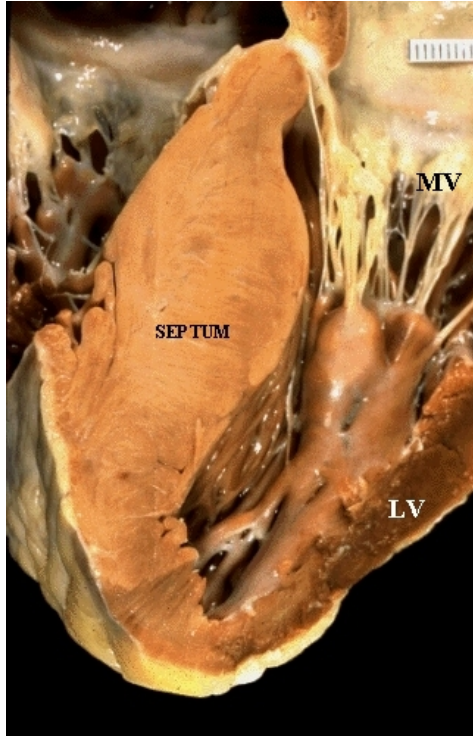


Methods and results

A tertiary centre prospective observational study was conducted. Detailed histopathological examination was performed in a tertiary centre specialized in the investigation of cardiac pathology in SCD. Hearts from 720 consecutive cases of SCD referred by coroners and pathologists from 2007 to 2009 were included. A comparison was drawn with diagnoses from referring pathologists. Most SCDs occurred in males (66%), with the median age being 32 years. The majority (57%) of deaths occurred at home. The main diagnoses were a morphologically normal heart ($n = 321$; 45%), cardiomyopathy ($n = 207$, 29%), and coronary artery pathology ($n = 71$; 10%). In 158 out of a sample of 200 consecutive cases, a cardiac examination was also performed by the referring pathologist with a disparity in diagnosis in 41% of the cases ($\kappa = 0.48$). Referring pathologists were more inclined to diagnose cardiomyopathy than normality with only 50 out of 80 (63%) normal hearts being described correctly.

Conclusion

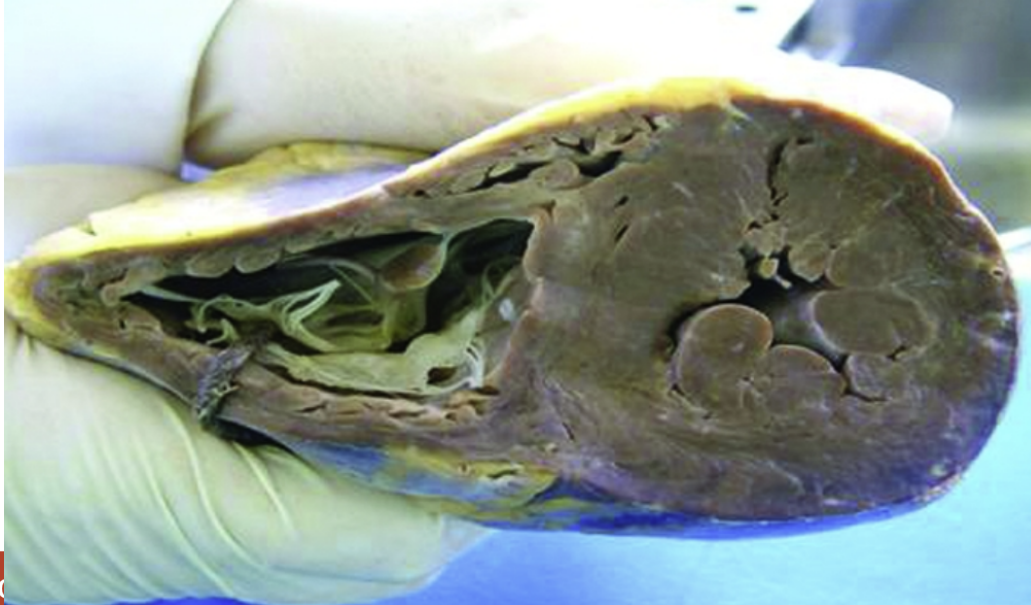
Expert cardiac pathology improves the accuracy of coronial post-mortem diagnoses in young SCD. This is important as the majority of cases may be due to inherited cardiac diseases and the autopsy guides the appropriate cardiological evaluation of blood relatives for their risk of sudden death.



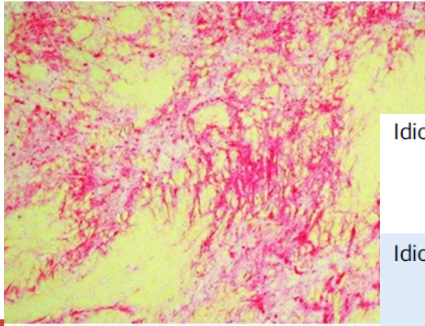
The most common cause of sudden death in athletes



Athlete in his 40s, dies suddenly during a half-marathon.... **Is this HCM?**



Idiopathic LVH



Idiopathic left ventricular hypertrophy

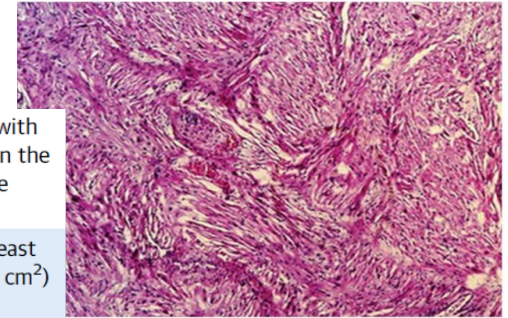
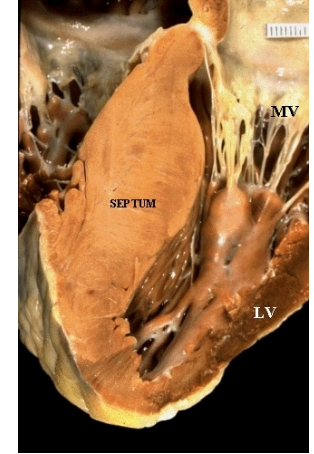
Idiopathic left ventricular fibrosis



Left ventricular wall thickness
>15 mm and heart weight
>500 g*

Normal heart weight and wall
thickness with/without
scarring macroscopically

Hypertrophic cardiomyopathy



Myocyte hypertrophy with
or without fibrosis in the
absence of myocyte
disarray

Fibrosis (>20% in at least
2 tissue blocks of 4 cm²)
with no myocyte
disarray

Diagnostic yield of hypertrophic cardiomyopathy in first-degree relatives of decedents with idiopathic left ventricular hypertrophy

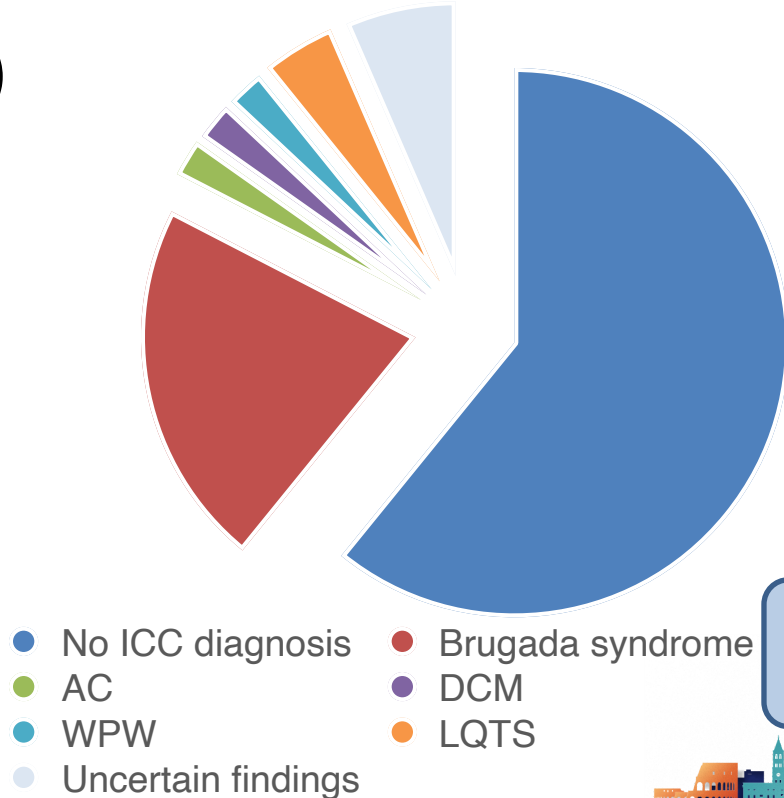
Gherardo Finocchiaro¹, Harshil Dhutia¹, Belinda Gray¹, Bode Ensam ¹, Stathis Papatheodorou¹, Chris Miles¹, Aneil Malhotra¹, Zeph Fanton¹, Paulo Bulleros¹, Tessa Homfray ¹, Adam A. Witney^{1,2}, Nicholas Bunce¹, Lisa J. Anderson ¹, James S. Ware³, Rajan Sharma¹, Maite Tome ¹, Elijah R. Behr ¹, Mary N. Sheppard ⁴, Michael Papadakis ^{1†}, and Sanjay Sharma ^{1*†}



Results of family screening (46 families, 125 family members)

Idiopathic LVH = HCM ?

**No HCM diagnosed
through family
screening**



HCM?



Factors associated with circumstances of death

- Death during exertion
- Death at rest
- Death during sleep

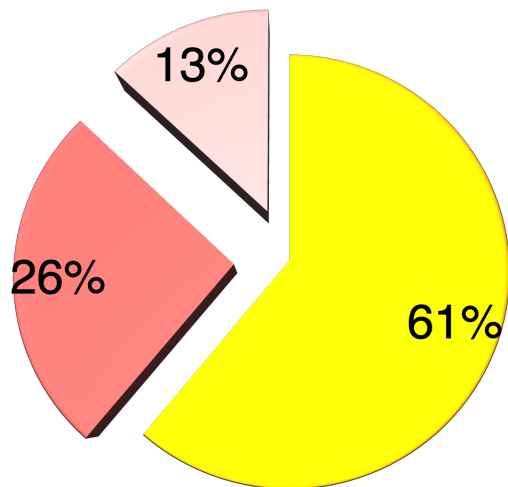
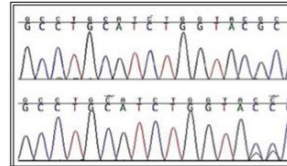


TABLE 3 Multivariate Analysis of Death During Exercise

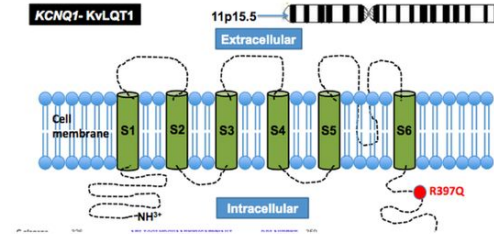
	Univariate Analysis		Multivariate Analysis	
	Hazard Ratio (95% CI)	p Value	Hazard Ratio (95% CI)	p Value
Male	1.29 (0.58-2.81)	0.534		
Age at death	0.99 (0.98-1.12)	0.946		
Caucasian ethnicity	1.09 (0.43-2.72)	0.85		
Family history of SD	0.96 (0.43-2.12)	0.93		
Competitive athlete	1.13 (0.71-1.8)	0.59		
LV fibrosis	2.43 (1.48-4.01)	<0.001	2.11 (1.15-3.88)	0.01
Heart weight*	0.96 (0.95-0.97)	0.001		
ARVC	8.36 (2.93-23.84)	<0.001	6.01 (1.97-18.32)	0.001
Coronary artery anomaly	5.32 (1.20-23.51)	0.008		
SADS	0.44 (0.29-0.68)	0.002		
HCM	0.80 (0.34-1.88)	0.613		

Molecular Autopsy



Genetic analysis

- Sanger sequencing
- Cardiac gene panels
- Whole exome / genomes



Pathogenic
(disease-causing)
mutation

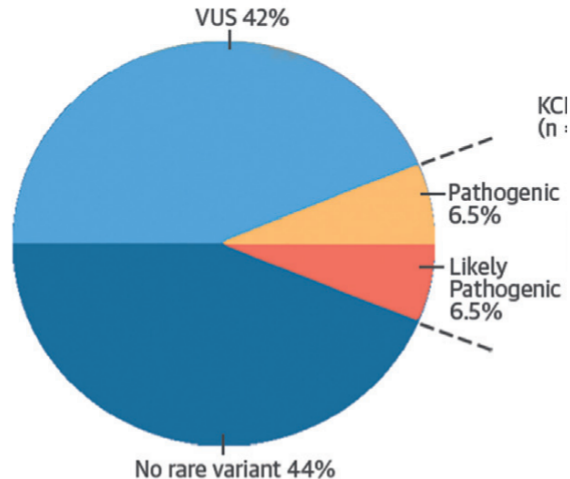


Utility of Post-Mortem Genetic Testing in Cases of Sudden Arrhythmic Death Syndrome



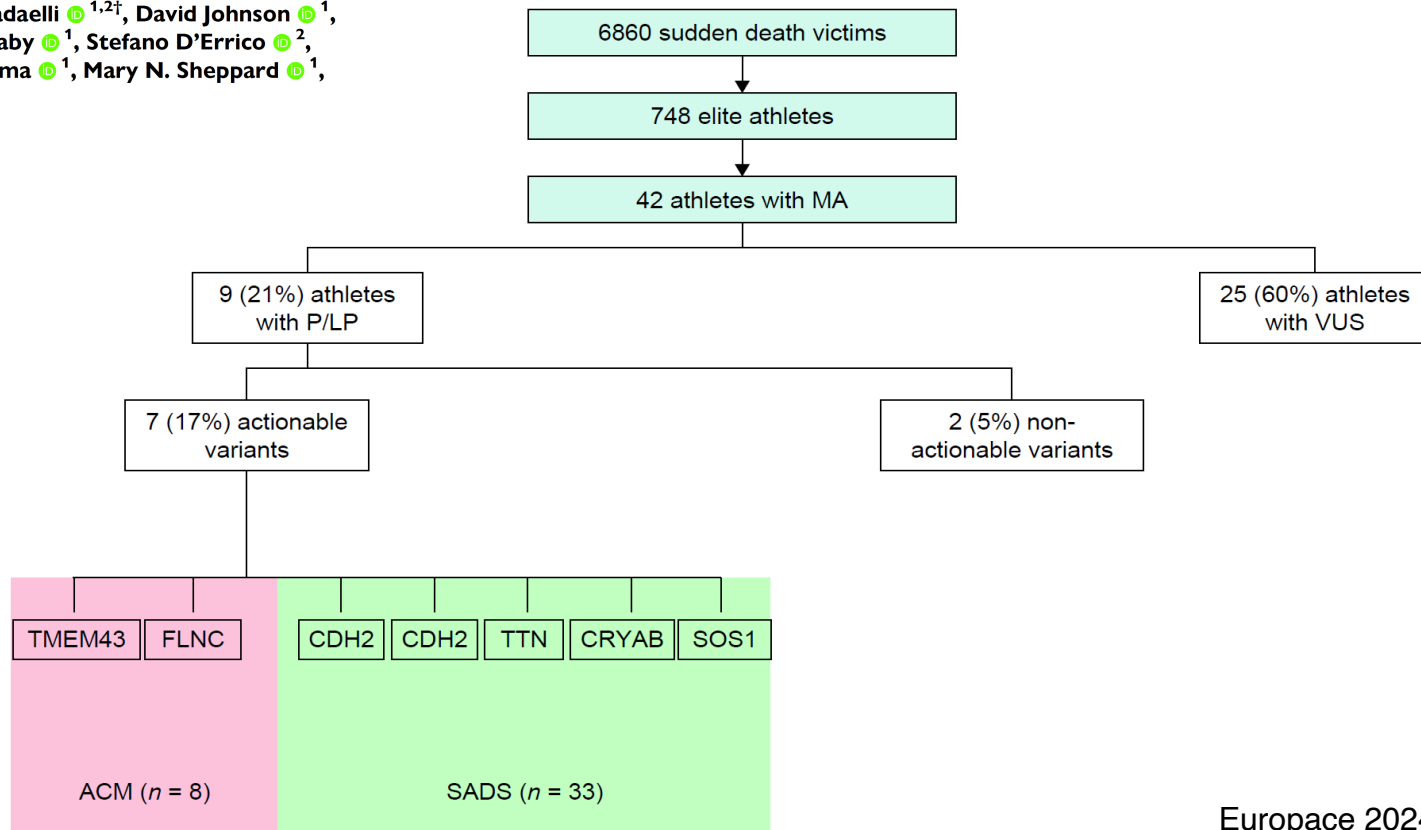
Najim Lahrouchi, MD,^a Hariharan Raju, MBChB, PhD,^{b,c} Elisabeth M. Lodder, PhD,^a Efstathios Papatheodorou, MD,^{b,c} James S. Ware, PhD,^{d,e} Michael Papadakis, MBBS, MD,^{b,c} Rafik Tadros, MD, PhD,^{a,f} Della Cole, BSc,^{b,c} Jonathan R. Skinner, MBChB, MD,^g Jackie Crawford,^g Donald R. Love, PhD,^g Chee J. Pua, PhD,^h Bee Y. Soh, PhD,^h Jaydutt D. Bhalshankar, PhD,^h Risha Govind, MSc,^{d,e} Jacob Tfelt-Hansen, MD, DMSc,ⁱ Bo G. Winkel, MD, PhD,ⁱ Christian van der Werf, MD, PhD,^a Yanushi D. Wijeyeratne, BMBS,^{b,c} Greg Mellor, MBChB, MD,^{b,c} Jan Till, MD,^{c,d,e} Marta C. Cohen, MD, DMJ (PATHOL),^j Maria Tome-Esteban, MD, PhD,^{b,c} Sanjay Sharma, MBChB, MD,^{b,c} Arthur A.M. Wilde, MD, PhD,^{a,k} Stuart A. Cook, MD, PhD,^{d,h,l} Connie R. Bezzina, PhD,^a Mary N. Sheppard, MB, BCH, BAO, MD,^{b,c} Elijah R. Behr, MBBS, MD^{b,c}

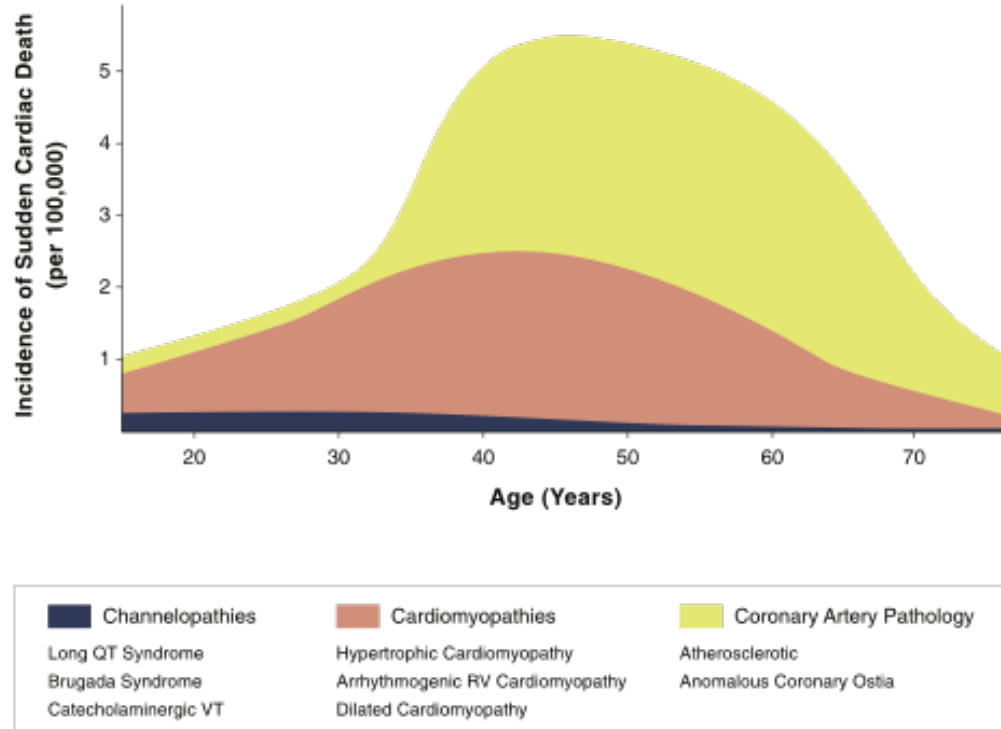
A. Yield of Genetic Testing in 302 SADS Cases



Yield of molecular autopsy in sudden cardiac death in athletes: data from a large registry in the UK

Gherardo Finocchiaro^{1†}, Davide Radaelli^{1,2†}, David Johnson¹,
Raghav T. Bhatia¹, Joseph Westaby¹, Stefano D'Errico²,
Michael Papadakis¹, Sanjay Sharma¹, Mary N. Sheppard¹,
and Elijah R. Behr^{1*}



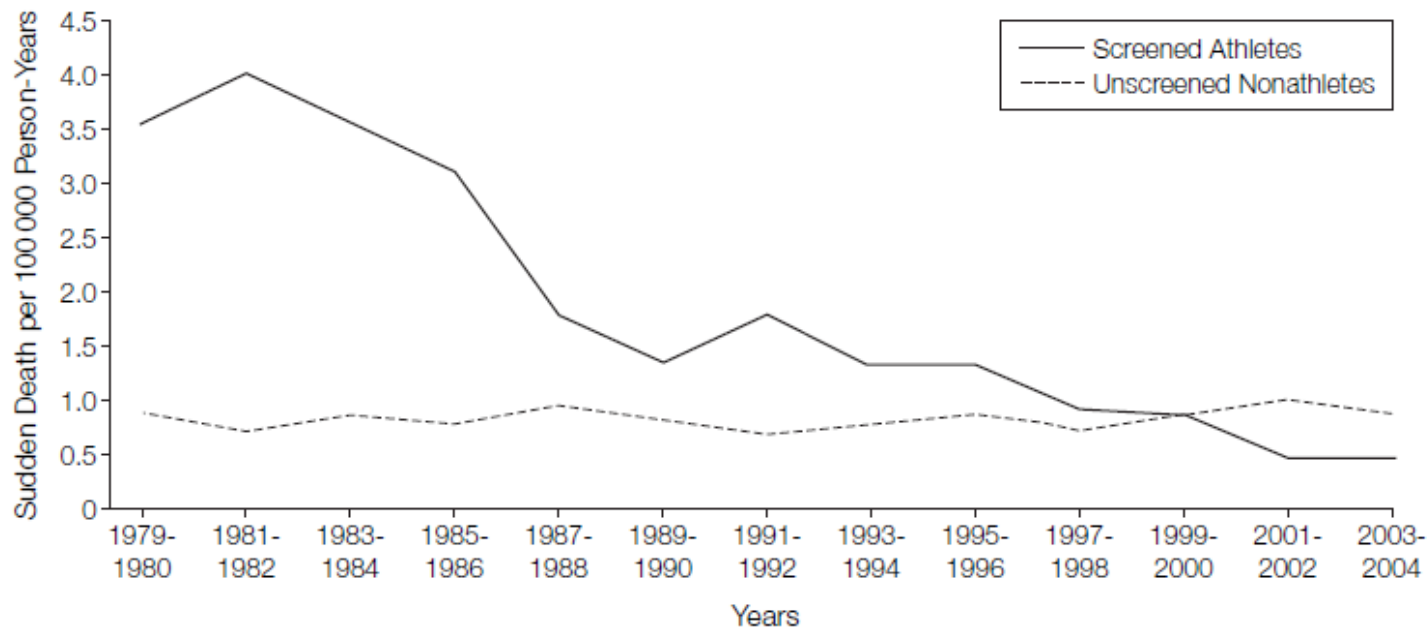


La Gerche et al.



Can we prevent it?





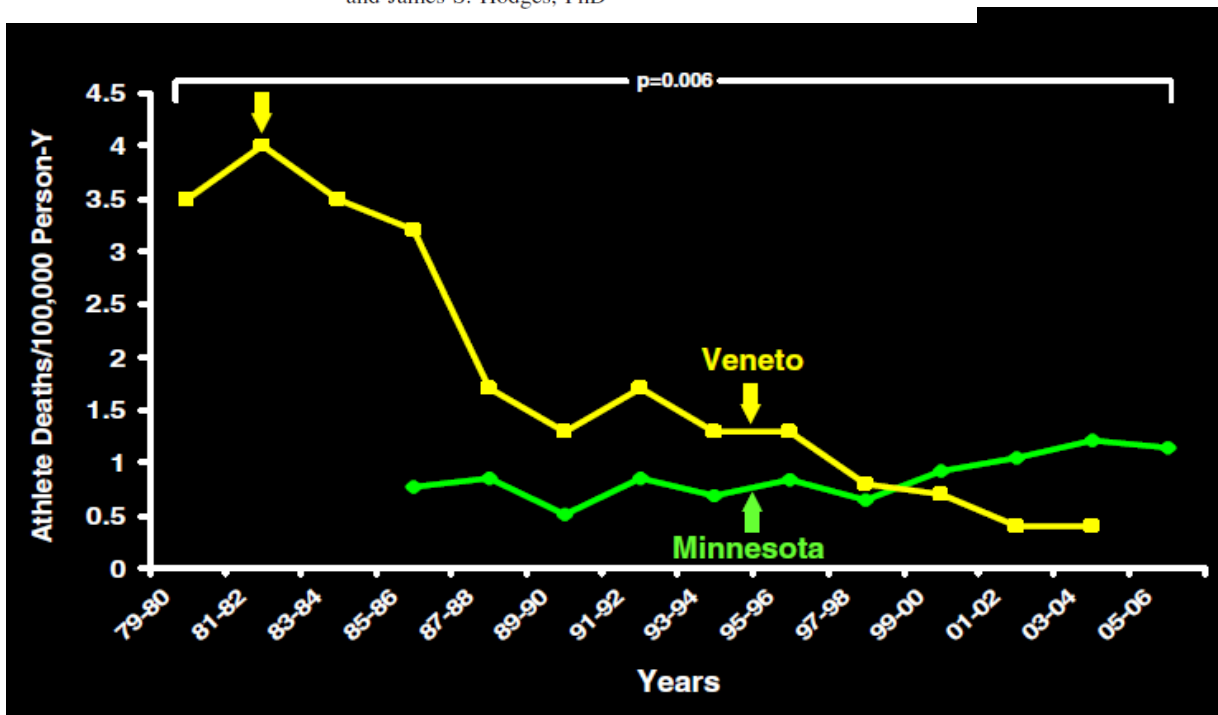
Annual Incidence Rates of Sudden Cardiovascular Death in Screened Competitive Athletes and Unscreened Non-athletes Aged 12 to 35 Years in the Veneto Region of Italy (1979-2004)

Corrado, et al. JAMA 2006



Comparison of U.S. and Italian Experiences With Sudden Cardiac Deaths in Young Competitive Athletes and Implications for Preparticipation Screening Strategies

Barry J. Maron, MD^{a,*}, Tammy S. Haas, RN^a, Joseph J. Doerer, BS^a, Paul D. Thompson, MD^b,
and James S. Hodges, PhD^c

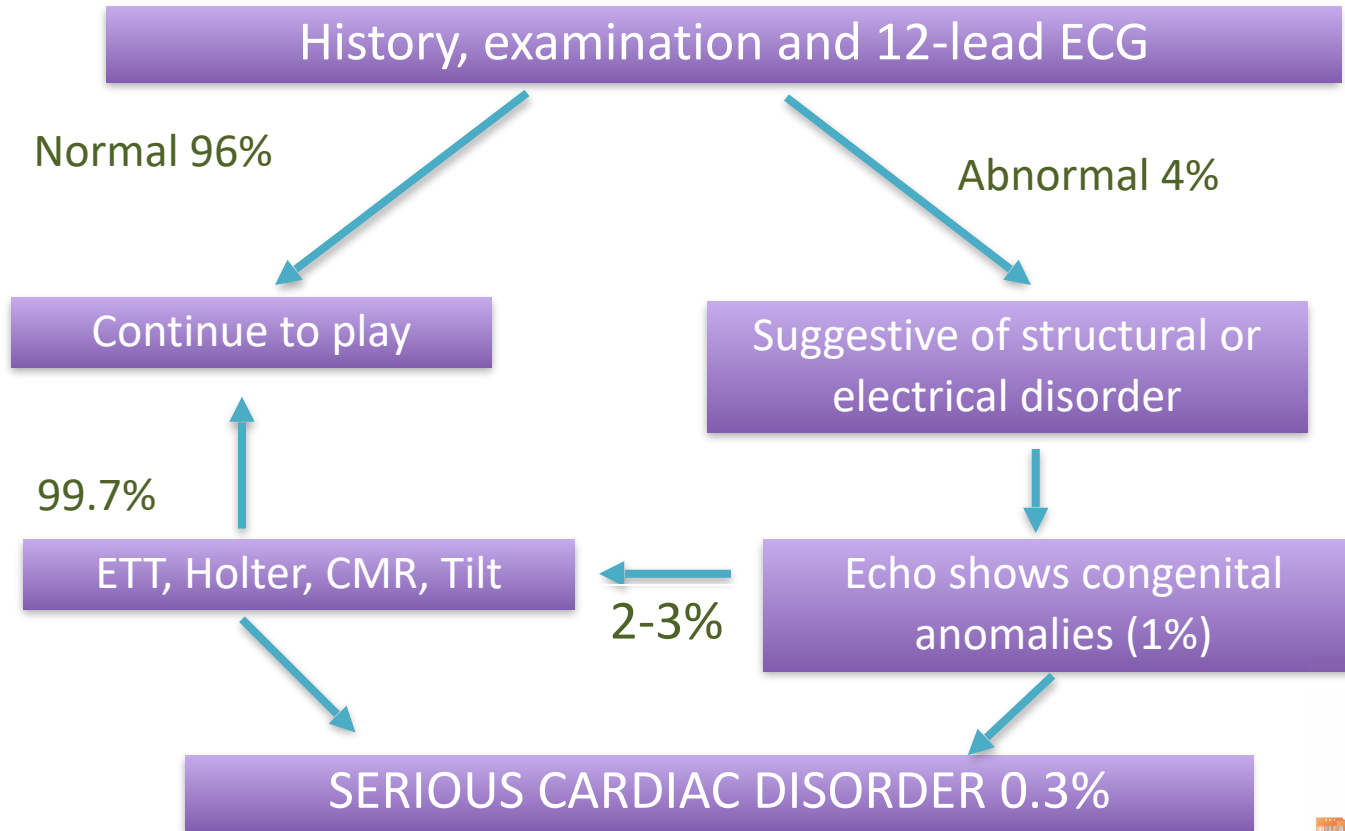


Corrado et al. JAMA 2006; 296: 1593-601

Maron et al. Am J Cardiol 2009; 104: 276-280



CRY Screening Programme

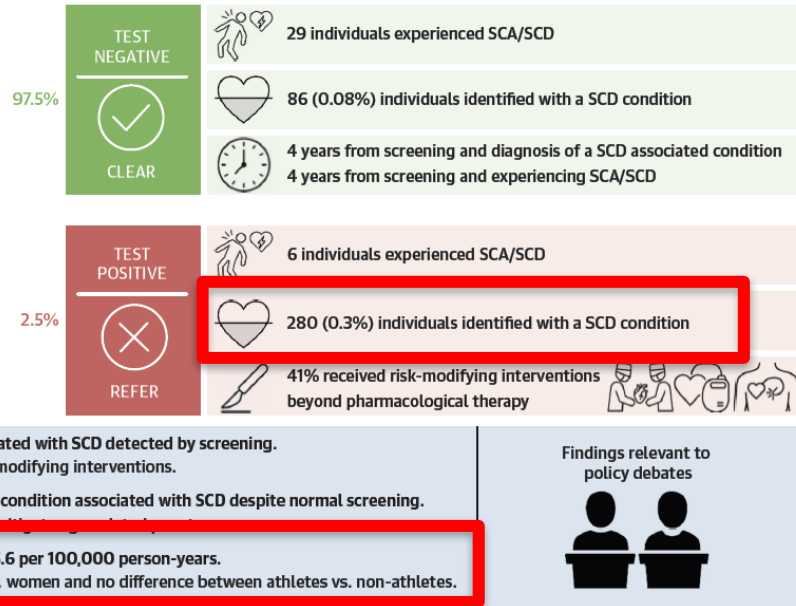
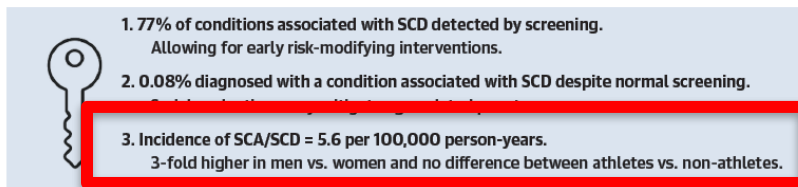
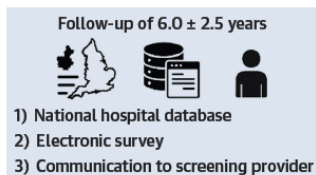
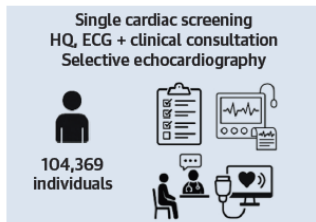


ORIGINAL RESEARCH

Cardiac Screening for Conditions Associated With Sudden Cardiac Death

Yield, Interventions, and SCA/SCD Incidence in 104,369 Young Individuals

Hamish MacLachlan, MD,^a Raghav Bhatia, PhD,^a Hariharan Raju, PhD,^b Greg Mellor, MD,^c Emmanouil Androulakis, PhD,^a Joyee Basu, PhD,^a Elijah R. Behr, MD,^{a,d} Navin Chandra, MD,^e Nikhil Chatrath, MD,^a Harshil Dhutia, MD,^f Andrew D'Silva, PhD,^g Saad Fyyaz, MD,^a Sabiha Gati, PhD,^g Aneil Malhotra, PhD,^h Sarandeep Marwaha, PhD,^a Chris Miles, PhD,^g Lynne Millar, MD,^g Keerthi Prakash, MD,ⁱ Sreenivasa Rao Kondapally Seshasai, PhD,^{a,d} Nabeel Sheikh, PhD,^g Mark Specterman, PhD,^{a,d} Malte Tome, MD,^{a,d} Abbas Zaidi, MD,^j Gherardo Finocchiaro, PhD,^{a,d} Sanjay Sharma, MD,^{a,d,k,*} Michael Papadakis, MD^{a,d,k,*}



MacLachlan H, et al. JACC. 2026;87(7):756-768.



Correspondence to: H Van Brabandt hans.vanbrabandt@kce.fgov.be

Accepted 15 February 2016

Sudden cardiac death of young athletes needs to be avoided but does screening really help?

Hans Van Brabandt and colleagues look at the evidence

Sudden cardiac death of a young person on a sports field is a devastating event. Often these deaths are due to an unrecognised underlying heart condition, and screening has been proposed as a method to prevent them.

However, disagreement remains about its benefits and harms.

Heartwire from Medscape

Review Recommends Skipping Sudden Cardiac Death Screening in Young Athletes

Patrice Wendling

April 25, 2016

17 comments



Print



Email

RELATED LINKS



'Silent Majority' of Young Nonathletes Also at Risk for SCD

BRUSSELS, BELGIUM — Screening young athletes with physical examination, history taking, and resting ECG to prevent sudden cardiac death (SCD) should be abandoned, according to a new review of the literature^[1].

The researchers, led by cardiologist Dr Hans Van Brabandt



"First we're going to run some tests to help pay off the machine."



Concerns relating to PPS

- Low incidence of SCD in young athletes
- Diverse disorders
- Cost of screening
- Lack of facilities and expertise
- False negatives
 - Structural heart disease
- False positive rates
 - Potential for increased anxiety
 - Increased cost
 - FALSE DISQUALIFICATION



Deaths Despite Screening with ECG

False Negatives

Anomalous coronary
arteries

Premature atherosclerotic
coronary disease

Adrenergically driven ion
channel disorders

Incomplete expressions of
cardiomyopathy

Acquired conditions

Commotio cordis

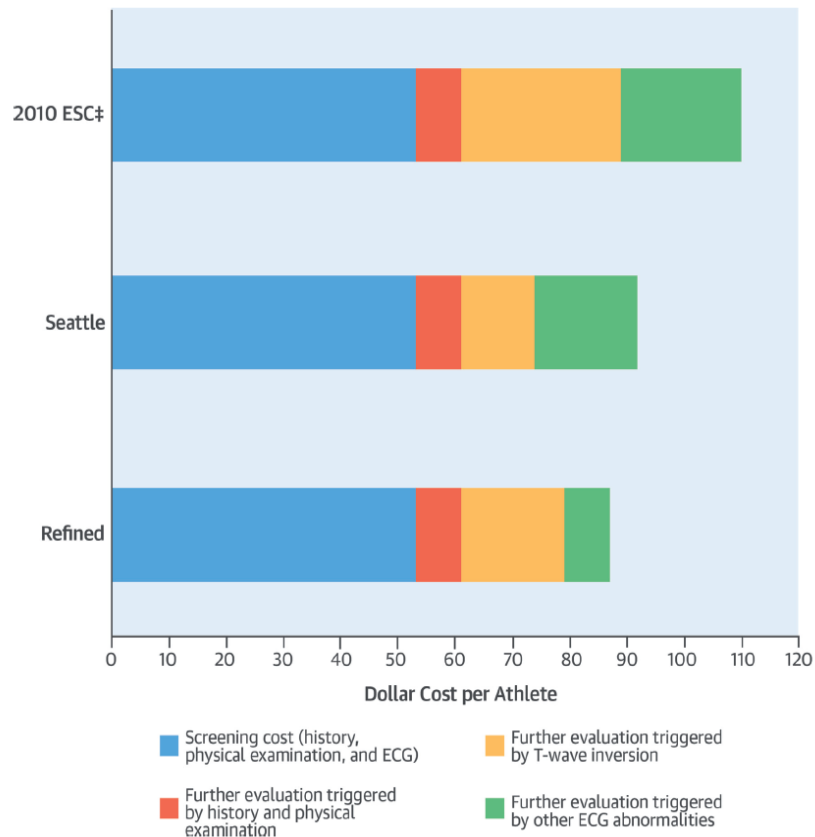
Myocarditis

Electrolyte disorders



Costs?





Dhutia, H. et al. J Am Coll Cardiol. 2016;68(7):702-11.

2010 ESC recommendations

Cost per athlete: \$110
Cost per diagnosis: \$35,993

Seattle criteria

Cost per athlete: \$92
Cost per diagnosis: \$30,251

International criteria

Cost per athlete: \$87
Cost per diagnosis: \$28,510

**21% cost
reduction**

Dhutia et al. JACC.
2016

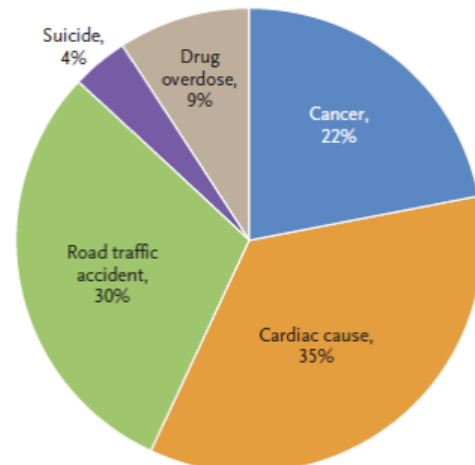


ORIGINAL ARTICLE

Outcomes of Cardiac Screening in Adolescent Soccer Players

Aneil Malhotra, M.B., B.Chir., Ph.D., Harshil Dhutia, M.B., B.S.,
 Gherardo Finocchiaro, M.D., Sabiha Gati, M.B., B.S., Ph.D.,
 Ian Beasley, M.B., B.S., Paul Clift, M.B., B.S., M.D., Charlotte Cowie, M.B., B.S.,
 Antoinette Kenny, M.B., B.S., M.D., Jamil Mayet, M.B., B.S., M.D.,
 David Oxborough, Ph.D., Kiran Patel, M.B., B.Chir., Ph.D.,
 Guido Pieves, M.B., B.S., Ph.D., Dhruvo Rakhit, M.B., B.S., Ph.D.,
 David Ramsdale, M.B., B.S., M.D., Leonard Shapiro, M.B., B.S., M.D.,
 John Somauroo, M.B., B.S., Graham Stuart, M.B., Ch.B.,
 Amanda Varnava, M.B., Chir.B., M.D., John Walsh, M.B., B.S., D.M.,
 Zaheer Yousef, M.B., B.S., M.D., Maite Tome, M.D., Ph.D.,
 Michael Papadakis, M.B., B.S., M.D., and Sanjay Sharma, M.B., Ch.B., M.D.

11,168 footballers
 Age: 16.4 ± 1.2 years
 Sudden death 6.8 : 100,000/year



Athlete No.	Sex and Age	Race*	Years from Screening to Death	Diagnosis	Initial Screening Result
1	M, 16.8 yr	Black	0.1	Idiopathic left ventricular hypertrophy	Negative
2	M, 16.6 yr	Mixed	1.0	Hypertrophic cardiomyopathy	Abnormal ECG and echocardiogram
3	M, 16.6 yr	Black	3.3	Hypertrophic cardiomyopathy	Negative
4	M, 16.3 yr	Black	7.7	Dilated cardiomyopathy	Negative
5	M, 17.0 yr	White	7.9	Arrhythmogenic right ventricular cardiomyopathy	Negative
6	M, 17.2 yr	White	9.7	Arrhythmogenic right ventricular cardiomyopathy	Negative
7	M, 15.7 yr	White	11.5	Hypertrophic cardiomyopathy	Abnormal ECG and echocardiogram
8	M, 16.8 yr	White	13.2	Sudden arrhythmic death syndrome	Negative

NEJM 2018

11,168 footballers



42 athletes - diagnosis
of serious cardiac condition



36/42 athletes had
an abnormal ECG

Condition	No. of Athletes	No. of Athletes with Abnormal Result			
		History	Examination	ECG	Echocardiography
Any cardiac condition	267	6	76	84	237
Condition associated with sudden cardiac death	42	3	2	36	12
Hypertrophic cardiomyopathy	5	0	0	5	5
Arrhythmogenic right ventricular cardiomyopathy	2	1	0	1	2
Dilated cardiomyopathy	1	1	0	1	1
Coronary-artery anomalies	2	0	0	0	2
Bicuspid aortic valve-associated disease*	3	1	2	0	3
Long-QT syndrome	3	0	0	3	0
Wolff-Parkinson-White ECG pattern	26	0	0	26	0
Other cardiac condition	225	3	74	48	225
Bicuspid aortic valve	68	1	32	15	68
Atrial septal defect	62	1	6	26	62
Aortic regurgitation	29	0	16	2	29
Mitral-valve prolapse	24	0	12	3	24
Patent ductus arteriosus	18	0	1	1	18
Ventricular septal defect	13	0	3	1	13
Pulmonary stenosis	9	1	4	0	9
Cor triatriatum	2	0	0	0	2

Malhotra et al, NEJM 2018



Take home messages

- Sudden cardiac death in young athletes is rare (more common than previously thought), but its impact is devastating
- Young athletes who experience sudden cardiac arrest have an underlying cardiac condition (controversies about predominant aetiology) that can be identified before an event
- Screening is important, but emergency preparedness saves lives
- The goal is not to disqualify athletes, but to enable safe participation

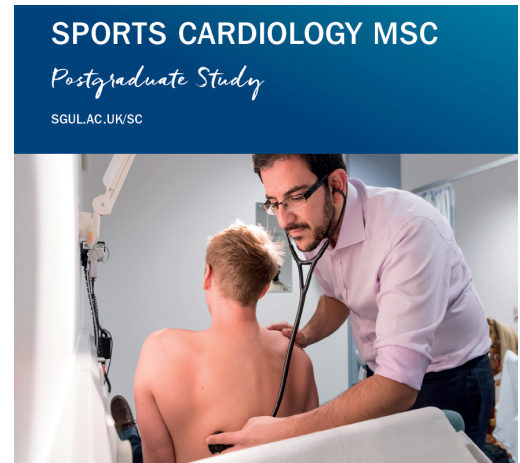




MSc in Sports Cardiology

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***Thanks for your
attention***

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