Sports-Related Sudden Cardiac Deaths in Singapore – An Eleven-Year Review

Dear Editor,

Sports-related sudden cardiac death (SCD) is a rare but tragic event. The absolute incidence has ranged from 1/80,000 to 1/200,000—depending on the type of sport, competitive nature of the sport, geographical region and methodology used in the analysis.[1-5] Amongst young athletes—arbitrarily defined as <35 years old—hypertrophic cardiomyopathy (HCM) and arrhythmogenic right ventricular dysplasia (ARVD) have been reported as the most common causes of sports-related SCD in the United States and Italy, respectively.[2] In older athletes >35 years old, ischaemic heart disease (IHD) has consistently ranked as the most common cause. However, not all reported sports-related SCDs have been adjudicated by autopsies.[3-5]

Understanding the epidemiology of sports-related SCD has impact on planning of preparticipation screening and in evaluating the utility of various cardiac screening tests.[6]

Definitions

SCD is defined as sudden unexpected death in a healthy individual attributable to either structural heart disease or arrhythmia, within 1 hour of onset of symptoms. Sports-related sudden death (SD) is defined to occur within 24 hours of sports participation. Sudden arrhythmic death syndrome (SADS) is defined as death from cardiac arrest with no identifiable structural heart pathology. Postmortem studies have shown that a substantial proportion of cardiac arrest victims with SADS had inherited arrhythmogenic disease, suggesting these deaths could be arrhythmia-driven, and were classified as cardiac deaths in our study.[7-8]

A sport event was classified as competitive if it was organised by an officially recognised sports association and non-competitive, if otherwise or recreational. Deaths during the Individual Physical Proficiency Test (IPPT) were classified as non-competitive.[9]

Long distance endurance events were defined as competitive events >20 km in distance and included running, cycling and swimming segments. Short run events spanned <10 km.

The participants were divided into young and older groups with age cutoff of 35 years old.

Participants with cardiovascular risk factors (CVRFs)—defined as hypertension, hyperlipidaemia, diabetes or pre-existing IHD—were identified.

Materials and Methods

This is a 11-year retrospective nationwide epidemiological study on sports-related SDs from January 2005 to December 2015 in Singapore based on the registry of the Health Sciences Authority (HSA), the national centre where deaths of uncertain causes are reported and autopsies performed. The registry was combined with information from the media and registry data of Sport Singapore, Singapore's main sport regulatory body. Relevant information was also obtained from hospital and paramedic records.

Deaths were segregated into 3 categories: A – cardiac deaths with structural heart pathology on autopsy, B – SADS, and C – non-cardiac deaths (similar to a previous study which reviewed SCD in the young).[10]

Incidence of sports-related SDs in our population was calculated using mean number of sports-related SDs per annum from 2005 to 2015, divided by the mean mortality from all causes in the population as the denominator.

Autopsy

Autopsies were performed at the Forensic Medicine Division (FMD) according to a standardised protocol as described elsewhere.[2]

Statistical Analysis

Statistical analysis was performed using SPSS software, version 22.0 (IBM).

Ethics

This study had been approved by the SingHealth Centralised Institutional Review Board (CIRB).

Results

Demographics

All 83 SDs underwent autopsy; 72 out of the 83 sports-related SDs (86.7%) were due to SCD, inclusive of SADS and deaths with structural heart pathology.

Approximately two-thirds of all SDs occurred in the Chinese (67.5%) and were predominantly male in both the young and older participant groups (23/25, 92% and 58/58, 100%, respectively). Older participants were more likely to have at least 1 CVS risk factor (41.4%) compared to younger ones (4%) (Table 1).

Amongst the 72 cases of SCD, 70.8% occurred in older participants (n = 51) which were almost entirely attributed to IHD (n = 50), with only 1 death from SADS (Table 2). SCD in young participants (n = 21, 29.2%) was also predominantly due to IHD (n = 9/21, 42.9%) (Table 2). Other cardiac causes include myocarditis (n = 3), anomalous coronary arteries (n = 2), cardiomyopathy (n = 4), aortitis (n = 1) and SADS (n = 2).

Amongst young SCDs, 4 patients died from dilated cardiomyopathy, none of whom showed any definitive features of HCM/ARVD. The young death from aortitis was a 12-year-old male who had Takayasu's arteritis with occluded coronary ostia from intimal thickening extending from the proximal ascending aorta. Amongst the young deaths from myocarditis, there was a 20-year-old male who was found to carry the *G643S-KCNQ1* gene that is associated with long QT syndrome.[11] There was a 14-year-old male with transposition of the great arteries whose autopsy revealed transmural acute myocardial infarction and fibrofatty replacement of the left ventricle. Although ARVD is known to affect the left ventricle as well, histological features in this case were still insufficient for definitive diagnosis of ARVD. His cause of death was attributed to IHD instead.

SCD also occurred more frequently during non-competitive (63/72,87.5%) compared to competitive sports (9/11, 81.8%) (Table 2). The 3 most common sports engaged in at the time of death were jogging, soccer and gym exercise (Table 3).

Table 1. Demographic Profile of Sports Participants with Sports-Related Sudden Deaths and Sudden Cardiac Deaths Stratified by Age

	Sudden Death (n = 83)			**Sudden Cardiac Death (n = 72)**		
	(n = 83)	**Age Group**		**(n = 72)**	**Age Group**	
		≤35 (n = 25)	**>35 (n = 58)**		**≤35 (n = 21) (29.2)**	**>35 (n = 51) (70.8)**
Mean age		41.8			42.2	
Male	81 (97.6)	23	58	70 (97.2)	19	51
Female	2 (2.4)	2	0	2 (2.8)	2	0
Ethnicity						
Chinese	56 (67.5)	14	42	48 (66.7)	12	36
Malay	10 (12.0)	7	3	8 (11.1)	5	3
Indian	5 (6.0)	0	5	5 (6.9)	0	5
Others	12 (14.5)	4	8	11 (15.3)	4	7
CVRFs/history of IHD	25 (30.1)	1 (4.0)	24 (41.4)	21 (29.2)	1 (4.8)	20 (39.2)
Hyperlipidaemia	10	1	9	10	1	9
Diabetes	2	0	2	2	0	2
Hypertension	9	0	9	6	0	6
IHD	4	0	4	3	0	3
>1 CVRFs/IHD	5	0	5	4	0	4
Competitive	11 (13.3)	5	6	9	4	5
Non-competitive	72 (86.7)	20	52	63	17	46
Type of rhythm						
Asystole	30 (36.1)	6	24	26 (36.1)	6	20
VF	28 (33.7)	6	22	27 (37.5)	6	21
PEA	4	2	2	4	2	2
Pulseless VT	1	1	0	1	0	1
Sinus rhythm	1	0	1	0	0	0
Idioventricular rhythm	1	1	0	1	1	0
Unknown	18	9	9	13 (18.1)	6	7

CVRFs: Cardiovascular risk factors; IHD: Ischaemic heart disease; PEA: Pulseless electrical activity; VF: Ventricular fibrillation; VT: Ventricular tachycardia
Percentages (%) are in parentheses ( ).

Table 2. Aetiologies of Sudden Cardiac Deaths and Non-Cardiac Deaths Stratified by Age, Competitive Nature of the Sport and Long Distance Endurance Events

		Age Group		Competitive vs Non-Competitive				Long Distance Endurance Event Participants	
		≤35 (n = 21)	>35 (n = 51)	Competitive (n = 9)		Non-Competitive (n = 63)		≤35 (n = 3)	>35 (n = 3)
Cardiac deaths	(n = 72)								
IHD	59 (81.9)	9 (42.9)	50 (98.0)	1	5	8	45	1	3
Cardiomyopathy	4	4	0	0	0	4	0	0	0
Myocarditis	3	3	0	1	0	2	0	0	0
Anomalous coronary arteries	2	2	0	2	0	0	0	2	0
Aortitis	1	1	0	0	0	1	0	0	0
SADS	3	2	1	0	0	2	1	0	0
Non-cardiac deaths	(n = 11)	(n = 4)	(n = 7)	(n = 2)		(n = 9)		(n = 2)	
Drowning	2	1	1	0	1	1	0	0	1
Traumatic head injury/ICH	7	1	6	0	0	1	6	0	0
Pneumonia	2	2	0	1	0	1	0	1	0

ICH: Intracerebral haemorrhage; IHD: Ischaemic heart disease; SADS: Sudden arrhythmic death syndrome

Table 3. Types of Sports Activities Patients Were Engaged in at Time of Collapse

Type of Exercise	n	Percentage (%)
Jogging	15	18.1
Soccer	11	13.3
Gym/treadmill	8	9.6
Marathons/long distance endurance events	8	9.6
Basketball	6	7.2
Short run event	6	7.2
Badminton	5	6.0
Cycling	4	4.8
Golf	4	4.8
Squash	3	3.6
Swimming	3	3.6
Warm up exercises	2	2.4
Brisk walking	1	1.2
IPPT	1	1.2
Rock climbing	1	1.2
Running	1	1.2
Tennis	1	1.2
Other sports	3	3.6

IPPT: Individual Physical Proficiency Test

The mean mortality from all causes in the population as retrieved from the local census[12] from 2005 to 2015 was 17,853. The mean mortality from sports-related SDs in each category were: A – 6.27, B – 0.27, and C – 1. The overall incidence of sports-related SDs was low at 0.00043, and this was contributed mainly by sports-related SCD, with an incidence of 0.00037. The incidence of sports-related SADS was very low at 0.00002.

Long Distance Endurance Event Participants

The long distance endurance events in this study included triathlons, a biathlon, a cyclothon and marathons. There were a total of 8 reported deaths in the long distance endurance event group over the 11 years, of which, 6 were SCDs (Table 2). All involved males with half of them aged <35 years old.

Amongst the 4 younger deaths, 2 (50%) were due to anomalous coronary arteries, 1 was due to IHD, and the last was attributed to pneumonia. There were 3 deaths in the older age group due to IHD.

Cardiac Rhythm on Collapse

Approximately one-third of SCDs presented in ventricular fibrillation (VF) (n = 27, 37.5%) and another one-third in asystole (n = 26, 36.1%). A significant number had no documented rhythm on record (n = 13, 18.1%) (Table 2). Only 53% of all participants received bystander cardiopulmonary resuscitation (CPR).

Discussion

The vast majority of sports-related SDs were SCDs, with the most common cause of SCD being IHD, occurring mainly in older male participants. This is consistent with the higher prevalence of IHD among the older population and increasing sports participation in this group.[1,5] In addition, the male predominance of SCD concurs with previous studies which have suggested IHD may be less prevalent in young women, and that women were more likely to be successfully resuscitated.[13]

However, for the younger SCDs, there was surprisingly not a single case of definitive HCM/ARVD on autopsy (contrary to Caucasian data). This was similar to findings in a recent Canadian study.[1] Instead, IHD was the most common cause of SCD amongst young participants. This may be attributed to the rising incidence of obesity, and increased prevalence of IHD in obese individuals.[14] Hence, CVRF control should start as young as possible.

There were only 6 reported SCDs involving long distance endurance events over the last 11 years. Given the large numbers of runners that participate in such runs annually, the incidence of SCD during long distance endurance events is expected to be very low, similar to an American study in marathon runners.[15] A third of deaths in long distance endurance events were from silent congenital anomalous coronary arteries, a common cause of SCD in young athletes.[16] In our study, there were a total of 3 reported cases of anomalous coronary arteries—2 with malignant interarterial route, while the third had a prepulmonic course. This reiterates the importance of looking for the coronary ostia in preparticipation echocardiograms. In the third case, the cause of death was thought to be unlikely related to the prepulmonic anomalous coronary artery, and was classified as SADS.

Currently, participants are encouraged to do a preparticipation questionnaire (American Heart Association/ Physical Activity Readiness Questionnaire [AHA/ PAR-Q]).[17] The value of a screening stress electrocardiogram (ECG) to ascertain fixed coronary stenosis is uncertain, with concerns of false-positives in asymptomatic individuals. It has been proposed that the mechanism underlying cardiac arrest in marathon runners with IHD was due to demand ischaemia rather than acute plaque rupture. Our study concurs with these findings, since the deaths from IHD did not show evidence of acute plaque rupture on autopsy.[15,18]

Our findings also showed a higher prevalence of SCD during non-competitive sports. This was likely due to greater participation compared to competitive sports.

Deaths from ventricular tachycardia (VT) or VF could have been averted with the use of automated external defibrillators (AEDs) and bystander CPR, which are significant predictors of patient survival.[15,19] However, in our registry, only approximately half of the participants received bystander CPR. Increasing public education on CPR/AED use will improve resuscitation success and hence reduce SCD.

Similar to our study findings, an American study in middle-aged individuals showed that the prevalence of sports-related SCD is still relatively low. Physical activity tailored to individuals with CVRFs should still be advocated to help them maintain a healthy lifestyle.[20]

Limitations

The demographic profile of our participants should ideally have included other pertinent information such as body mass index, history of smoking and family history of IHD but this was not available.

As this is an autopsy series, we lacked data on survivors. Moreover, information on the number of long distance endurance event participants was not available from the organisers. Hence, the incidence of SCD in the total population of participants could not be calculated. The strikingly higher incidence of male SCD in our study could also have been reflected by greater male participation numbers compared to females but this information was not available.

It is possible that a proportion of "high-risk" participants had already undergone preparticipation screening and were barred from taking part in sports from the outset, and hence excluded from our study.

Not all sports-related SDs were reported to HSA, as local hospitals may have chosen to certify the cause of deaths without an autopsy. Thus, the registry data may not be comprehensive. In addition, it is not possible to ascertain whether deaths classified as non-cardiac by autopsy could be SADS.

Conclusion

The majority of sports-related SDs in Singapore is due to SCD, occurring mainly in older male athletes and during non-competitive sports. IHD is the most common cause of SCD, regardless of age.

Acknowledgement

The authors would like to thank Miss Carmen Kam (Clinical Trials and Research Unit, Changi General Hospital) for assistance on the statistical analysis of this paper.

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