A Lethal Blow to the Chest as an Underdiagnosed Cause of Sudden Death in United Kingdom Sports (Football, Cricket, Rugby)

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Nonpenetrating blunt force trauma to the front of the chest can lead to commotio cordis, a cardiac rhythm disturbance, which can result in cardiac arrest and death. The condition is particularly noted during sport. No series of such cases has been published in the UK. This study is a retrospective analysis of a database of 6000 cases of sudden cardiac death examining commotio cordis in the setting of collapse and death shortly following a blow to the precordium where no structural heart disease was identified at autopsy. Of the 17 cases, 16 were male, and 11 were 18 years old or younger. Eleven occurred whilst playing sport while 6 involved physical interaction including assault. The most common circumstance of death involved a youth being struck in the chest by a ball during sporting activity. In conclusion, this study demonstrates that cases of commotio cordis in the UK follow a similar circumstantial and age profile to those reported in the United States, and indicates that ball sports such as football, cricket, and rugby expose young participants to a similar risk. There is currently no nation-wide registry of deaths occurring during sporting activity in the UK, and although the true incidence of this condition is not currently known, it is most probably under-recognised and underdiagnosed. **(Am J Cardiol 2019;124:808−811)**

Introduction

A nonpenetrating blow to the chest in the area of the heart, termed commotio cordis, is a rare cause of sudden death in athletes. Disruption to the heart's rhythm leads to cardiac arrest in the absence of pre-existing or identifiable structural heart abnormalities (Figure 1).[1] From 2,406 young athlete deaths, as reported by the United States National Registry of Sudden Death in Athletes, Maron et al identified 216 (9%) confirmed cases of commotio cordis, with 53% occurring during organized sporting events and 75% being less than 18 years old.[2,3] In the UK, there is currently no national registry regarding sport-related deaths, and in our own publication on sudden death in sport, commotio cordis was not highlighted.[4] An in-depth analysis of our database of sudden cardiac death (SCD) was conducted to correlate and compare with the US study to assess the circumstances in UK sports, and to provide a broader definition of the condition outside of sports, highlighting the role of assault and the medico-legal implications. We explore the necessity of increased awareness, education, and documentation of the condition with the object of rapid resuscitation and sudden death prevention.

Method

The Cardiac Risk in the Young (CRY) Centre for Cardiovascular Pathology is a specialist referral centre for cases of suspected SCD across the UK, receiving ~800 cases per year and with a database of 6000 cases. We define SCD as a natural death occurring from a cardiac cause within 1 hour of onset of symptoms or within 24 hours of last being seen well. Pathological examination of all cases is conducted with consent of the coroner and next of kin according to specific guidelines, with all relevant information regarding the deceased provided by the referring pathologist/coroner.[5] The database contains information pertaining to the deceased such as age, sex, BMI and ethnicity, along with details of previous medical history, co-existing conditions, prescribed medications, drug/alcohol intake and relevant family history. Database fields completed for the pathological examination of the heart include weight, coronary artery assessment, atria size, ventricle chamber diameters, circumferential muscle and fat ventricular measurements, circumferential measurement of all valves and microscopic examination of histological sections.

Extraction of the database filtering for *commotio cordis* as cause of death was conducted with resulting cases analyzed based on patient details and circumstances of death. Inclusion criteria required no previous history of cardiac arrhythmia/abnormality, a morphologically normal heart, no cause of death identified at post-mortem and negative/non-lethal toxicology.

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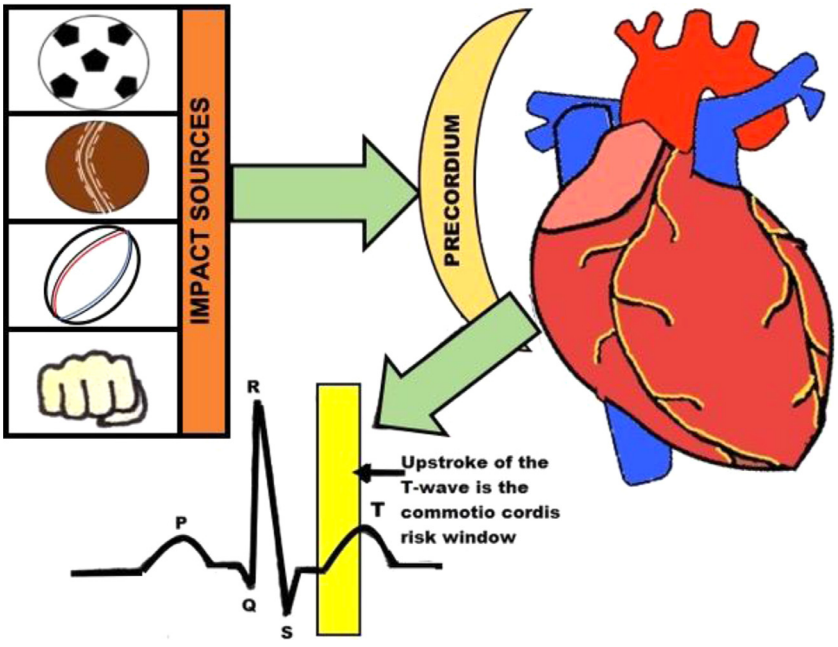

Figure 1. Diagram illustrating the mechanism behind the condition.

Results

Of the 6000 cases present in the CRY Database of SCD, 17 cases of SCD due to commotio cordis were found (Table 1). Sixteen were male, mean age was 19.1 ± 9.8 and 11 were 18 years old or younger. Eleven of the cases occurred whilst playing sport, primarily football, cricket, and rugby, and 3 cases occurred as a result of an assault. Two cases reported positive toxicology for nontoxic levels of alcohol and recreational drugs, of which 1 had a chest lesion and broken rib.

Discussion

This is the first detailed report to highlight commotio cordis in UK sport as a cause of SCD. Based on differences in population and identified cases, the incidence of commotio cordis is 21.6 times greater in the United States than in the UK.[6] This discrepancy could be due to differences in types of competitive sports undertaken in both countries. Some have proposed that participation in impact-based and aggressive sports is more common among American youth, thus exposing them to an increased risk for injury-related deaths.[7] Furthermore, the proportion of participating males over females could provide explanation for why male cases predominate. However, the numbers identified in the CRY database are likely to represent a significant under-estimation of the number of cases, since there is currently no national registry of deaths due to sporting activity in the UK, making it difficult to assess the true incidence of the condition. For example, in our study of SCD in sports by

Table 1
Age, sex and circumstances of the 17 commotio cordis cases recovered from the CRY Database of Sudden Cardiac Death

Case Year	Sex	Age at death	Object hitting chest	Post-trauma activity	Identifiable chest injuries
1994	Male	47	Cricket ball	Felt dizzy but scored a run before collapsing	0
1997	Male	12	Cricket ball	0	0
1997	Male	14	Football	0	0
1998	Male	13	Cricket ball	0	Bruise
1999	Male	15	500g stone during gang fight	0	0
1999	Male	19	Football	Stood in goal for 5−10 minutes before collapsing	0
2001	Male	12	Swing at playground	Died soon after being rushed to ER	0
2002	Male	17	Football	Revived twice, died in hospital	0
2005	Male	18	Cricket ball	0	0
2007	Male	9	Kicked by a horse	0	Faint bruise
2007	Male	16	Football	0	0
2012	Male	38	Assault	0	0
2012	Female	12	Rugby ball	0	0
2014	Male	23	Friend at a party	Spoke to friend	0
2015	Male	24	Cricket ball	0	0
2016	Male	21	Golf club during assault	Stumbled	Chest lesion, broken rib
2017	Male	15	Football	Spoke to friend	0

Finocchiaro et al, commotio cordis was not mentioned due to its rarity in comparison to other causes of SCD.[4] However, although rare, this study highlights the occurrence of commotio cordis in popular UK sports, and emphasizes caution as the mounting intensity and speed inherent in modern sports will possibly increase the likeliness of commotio cordis in the future.[8,9]

A study of the US Commotio Cordis Registry indicates a recent increase in survival cases which could be attributed to an increased availability of defibrillators, as well as improved awareness of the condition, as the majority of successful resuscitation cases occurred during organized sporting events rather than during recreational activities.[10] However, survival rates remain low, and it is possible that the significance of a blow to the chest may not be recognized due to unawareness of the condition, resulting in effective resuscitation methods being delayed.[10] Continuing efforts to train coaching staff and players in first aid, and ensure timely access to defibrillation, should reduce the associated overall mortality within the sporting community.

The proposed mechanism of tachyarrhythmia generation in commotio cordis is thought to be trauma to the chest wall during the T-wave of the cardiac cycle, known to be the vulnerable phase of cardiac repolarization.[11,12] As reported cases are found to largely affect younger individuals, it is suggested that transmission of energy from the site of impact to the myocardium is greater in the young due to a less developed, thinner, and more malleable chest wall.[13] Although the nature of the trigger mechanism remains to be validated, studies show the involvement of mechano-electric feedback acting via stretch-activated cation-selective channels, as their activation can initiate action potentials in isolated cardiac myocytes leading to premature ventricular excitation.[14] Although cardiovascular collapse due to rapid/"instantaneous" ventricular fibrillation is thought to occur in the large majority of cases, Maron et al report that 20% of victims remain physically active for a 'few seconds' after the blow.[15] The underlying rhythm disturbance in such cases is presumably tachyarrhythmia degenerating into ventricular fibrillation at a variable period of time, but likely within seconds, after the trauma.[16] Therefore, despite purposeful activity and a delay in ventricular fibrillation following a blow to the chest, a diagnosis of commotio cordis is not excluded. In coming to a conclusion about the cause, mechanism and manner of death, the forensic pathologist must take into account the history and circumstances and apply these to the findings at autopsy and the results of ancillary investigations.

The CRY Centre for Cardiovascular Pathology does not receive all cases of SCD within the UK, and our study does not include data relating to survivors of commotio cordis, thus the true incidence of the condition is not known. Additionally, although no genetic abnormalities were diagnosed prior to referral, no molecular autopsy was conducted as many were older cases dating back to 1994. However, the large number of referrals to our unit, along with the extent of information provided for each referral, suggests that our results are an accurate representation of frequency and circumstance of the condition.

Our study indicates that commotio cordis occurs in the UK with a demographic profile similar to that of US studies and demonstrates that young males undertaking organised sporting activities are at greatest risk, particularly those playing ball sports such as football, cricket, and rugby. Unlike in the United States, in the UK at present there is no national registry of young deaths during sporting activity, meaning that there is significant risk of under-reporting of this condition, leading to low public awareness. In a medico-legal setting, under-reporting of the condition may be due to a reluctance to accept the diagnosis where the temporal association between blow and collapse is prolonged or when stimulant drugs are found on toxicological analysis. In conclusion, although survival rates remain poor, rapid institution of resuscitation endeavours offer the best chance for survival. If in the UK we can build a national registry for deaths in sports and improve education for the identification and understanding of commotio cordis, along with implementation of rapid resuscitation, many young lives could be saved.

Disclosures

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

Contributions

S.C., N.W., and M.N.S. all contributed to the data collection, interpretation, and writing of the manuscript. B.J.M and K.M.H contributed to data collection and interpretation.

Supplementary materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.amjcard.2019.05.050.

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