



Original communication

## Sudden cardiac death among general population and sport related population in forensic experience



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### ARTICLE INFO

#### Article history:

Received 26 March 2015

Received in revised form

19 June 2015

Accepted 23 July 2015

Available online 1 August 2015

#### Keywords:

Sudden cardiac death

Coronary artery disease in the young

Sport-related deaths

Registries

### ABSTRACT

**Purpose:** The goal of the study was to assess the causes and analyze the cases of sudden cardiac death (SCD) victims referred to the department of forensic medicine in Lausanne, with a particular focus on sports-related fatalities including also leisure sporting activities. To date, no such published assessment has been done nor for Switzerland nor for the central Europe.

**Methods:** This is a retrospective study based on autopsy records of SCD victims, from 10 to 50 years of age, performed at the University Centre of Legal Medicine in Lausanne from 1995 to 2010. The study population was divided into two groups: sport-related (SR) and not sport-related (NSR) SCDs.

**Results:** During the study period, 188 cases of SCD were recorded: 166 (88%) were NSR and 22 (12%) SR. The mean age of the 188 victims was  $37.3 \pm 10.1$  years, with the majority of the cases being male (79%). A cause of death was established in 84%, and the pathology responsible for death varied according to the age of the victims.

In the NSR group, the mean age was  $38.2 \pm 9.2$  years and there was 82% of male. Coronary artery disease (CAD) was the main diagnosis in the victims aged 30–50 years. The majority of morphologically normal hearts were observed in the 15–29 year age range. There was no case in the 10–14 year age range.

In the SR group, 91% of victims died during leisure sporting activities. In this group the mean age was  $30.5 \pm 13.5$  years, with the majority being male (82%). The main cause of death was CAD, with 6 cases (27%) and a mean age of  $40.8 \pm 5.5$  years. The youngest victim with CAD was 33 years old. A morphologically normal heart was observed in 5 cases (23%), with a mean age of  $24.4 \pm 14.9$  years. The most frequently implicated sporting activities were hiking (26%) and swimming (17%).

**Conclusion:** In this study, CAD was the most common cause of death in both groups. Although this pathology most often affects adults over 35 years of age, there were also some victims under 35 years of age in both groups. SCDs during sport are mostly related to leisure sporting activities, for which preventive measures are not yet usually established. This study highlights also the need to inform both athletes and non athletes of the cardiovascular risks during sport activities and the role of a forensic autopsy and registries involving forensic pathologists for SR SCD.

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## 1. Introduction

Cardiovascular diseases are the most frequent causes of death in industrialized countries. Sudden cardiac arrest is a leading cause of

death in children and young adults<sup>1,2</sup> and can be caused by various heart diseases, such as coronary artery disease (CAD), hypertrophic cardiomyopathy (HCM), ILVH (idiopathic left ventricular hypertrophy), arrhythmogenic right ventricular cardiomyopathy (ARVC) and channelopathies.<sup>1,3,4</sup>

According to the literature, the most common cause of sudden cardiac death (SCD) in the general population is CAD related to coronary atherosclerosis. It occurs more frequently in adults over 35 years of age, but is also an important cause of death in younger

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victims especially during sport activities.<sup>2,5</sup> SCDs in young athletes receive considerable attention from the media and increase the awareness of screening programs. Public interest arises from both the importance of sports in many societies, and from the paradox that physical activities can have both a positive and negative impact on an individual's health.<sup>6</sup> According to several studies, sudden death from cardiovascular disease is the principal cause of death in young athletes during training, and accounts for 75% of all fatalities that occur during sport activities.<sup>1,7–9</sup> Regular physical activity has a protective influence on health, particularly the cardiovascular system, but it may become deleterious beyond a certain point and can precipitate the occurrence of complications related to pre-existing and silent cardiac diseases.<sup>4,6,8–17</sup> An unexpected and suspicious sudden death is often the first symptom of undiagnosed cardiac disease. In Switzerland, unexpected sudden deaths, including those which occur during physical activity, are considered as suspicious and are referred to the forensic medicine department.

The purpose of this study was to investigate the causes of SCD in individuals aged 10–50 years, who died either during sport (SR group) or not (not sport related group: NSR). Individuals included in the study were referred to the department of forensic medicine in Lausanne between 1995 and 2010. To date, only a few data has been published for Switzerland.<sup>6,18</sup>

## 2. Methods

### 2.1. Selection of cases

This retrospective study is based on a review of autopsy reports from the University Center of Forensic Medicine in Lausanne. Selected cases were of victims between 10 and 50 years of age who had a clinical history compatible with SCD defined as unexpected death occurring as a result of natural causes in which loss of all functions occurred instantaneously or within one hour of the onset of symptoms. We excluded cases with a non-cardiac cause of death found at autopsy or during toxicological analyses and cases showing marked putrefaction. We chose these age groups (10–50 years) in order to compare our results with existing studies. A subgroup was created for all cases of SCD which occurred during sport activity, including amateur and professional athletes,<sup>8</sup> high level sportsmen, and individuals practising leisure sport activities. We define a leisure sportsman as someone practicing a sporting activity 2–3 h per week, a high level sportsman as someone who trains more than 4 h per week and an athlete as someone with a regular and intense training who takes part in competitive sports. Cases were grouped according to the age with 5 years interval as for example; 10–14, 15–19, 20–24, etc.

### 2.2. Analysis of cases

The autopsies were performed according to international recommendations.<sup>19</sup> Toxicological analyses were performed in all cases for which no cause of death was established after morphological examination. Anti-doping analyses were performed for the athlete victim of SCD.

The following data were recorded in each case: cause of death, age, weight, height, body mass index (BMI), type of sporting activity (if applicable), symptoms before death, timing between physical activity and death, risk factor, personal history of cardiac disease, family history, general and cardiovascular medical history and the autopsy results, including complementary toxicological analyses and post-mortem molecular autopsy in selected recent cases. The final cardiovascular pathological diagnoses were classified into the following groups: CAD including acute (thrombosis) and chronic forms (stenosis superior to 75%), HCM and ILVH, ARVC, anomalous

origin of coronary artery, inflammatory disease (myocarditis/sarcoidosis), mitral valve prolapse, other valvular abnormalities, conduction system abnormalities and a morphologically normal heart.

## 3. Results

### 3.1. General results

Based on these criteria, 188 cases were selected. The mean age was  $37.3 \pm 10.1$  years (32.6 years for women and 38.6 years for men). The number of cases increased with age, especially in men (Fig. 1). The number of victim under 35 years old and under 39 years old was respectively 63 (33.5%) and 87 (46.3%). Among the 188 cases, 22 deaths (12%) occurred during sport activities (SR group). In the SR group, cases were distributed homogeneously among the age groups. There were 4 women (17%) and 18 men (82%). The mean age in the SR group was  $30.5 \pm 13.5$  years and there were 2 cases in the 10–14 year age group; both were females who died during sport activity. In the NSR group (166 cases), there were 36 women (22%) and 130 men (78%) and the mean age was  $38.2 \pm 9.2$  years.

The cause of death was established in 83.5% of cases (84.3% in the NSR group and 73.4% in the SR group). The hearts were morphologically normal in 16.5% of cases (15.7% in the NSR and 22.7% in the SR groups); for all of these cases, full toxicological and anti-doping analyses were performed and were found to be negative.

Molecular autopsies were proposed to investigating district attorney since the appearance of technical tools but considering their cost, this recommendation was accepted only in selected recent cases. Post-mortem genetic analyses were performed after genetic counseling of families using direct sequencing for the verification of genetic variants in *KCNH2*, *KCNQ1*, *SCN5A* and later also for *RyR2* gene mutations. Considering the complexity of post-mortem genetic testing in the forensic context, after the introduction of the Swiss Law of Genetic, the samples were stored for disposition of families and analyzed only after the contact of families and a multidisciplinary consultation. Post-mortem genetic testing for channelopathies was performed in nine cases and did not reveal any known mutation. The data concerning the medical and family history were collected by the police during the judicial investigations and transmitted to the forensic pathologists. Contact between the family doctor and the forensic pathologist was established in a few of the cases and negative information was not reported. A family history of cardiac-related death was reported in 12 cases (6.4%), including 10 men with CAD (8 in NSR group and 2 in SR group), one woman with HCM and another with a morphologically normal heart (both in the NSR group). A prodrome such as

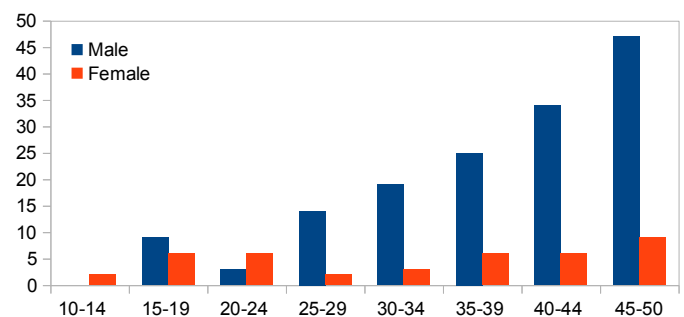


Fig. 1. Number of cases of presumed SCD according to age and gender in the studied population (n = 188). There is an increase with age in males, while female groups are more constant between different ages.

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