Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 58, No. 12, 2011
ISSN 0735-1097/$36.00
doi:10.1016/j.jacc.2011.01.049



# Sudden Death in Young Adults

## An Autopsy-Based Series of a Population Undergoing Active Surveillance

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**Objectives** The purpose of this study was to define the incidence and characterization of cardiovascular cause of sudden death in the young.

**Background** The epidemiology of sudden cardiac death (SCD) in young adults is based on small studies and uncontrolled observations. Identifying causes of sudden death in this population is important for guiding approaches to prevention.

**Methods** We performed a retrospective cohort study using demographic and autopsy data from the Department of Defense Cardiovascular Death Registry over a 10-year period comprising 15.2 million person-years of active surveillance.

**Results** We reviewed all nontraumatic sudden deaths in persons 18 years of age and over. We identified 902 subjects in whom the adjudicated cause of death was of potential cardiac etiology, with a mean age of 38 ± 11 years. The mortality rate for SCD per 100,000 person-years for the study period was 6.7 for males and 1.4 for females ($p < 0.0001$). Sudden death was attributed to a cardiac condition in 715 (79.3%) and was unexplained in 187 (20.7%). The incidence of sudden unexplained death (SUD) was 1.2 per 100,000 person-years for persons <35 years of age, and 2.0 per 100,000 person-years for those ≥35 years of age ($p < 0.001$). The incidence of fatal atherosclerotic coronary artery disease was 0.7 per 100,000 person-years for those <35 years of age, and 13.7 per 100,000 person-years for those ≥35 years of age ($p < 0.001$).

**Conclusions** Prevention of sudden death in the young adult should focus on evaluation for causes known to be associated with SUD (e.g., primary arrhythmia) among persons <35 years of age, with an emphasis on atherosclerotic coronary disease in those ≥35 years of age. (J Am Coll Cardiol 2011;58:1254–61) © 2011 by the American College of Cardiology Foundation

Sudden death of the healthy young adult is uncommon, but receives substantial attention from the media and raises issues of accountability for screening programs (1). The relative importance of different etiologies of sudden death varies among studies. Among cohorts collected using passive surveillance (e.g., newspaper accounts and Internet queries), hypertrophic cardiomyopathy was the most commonly identified abnormality in sudden death of young adults and young athletes (2–4). Passive surveillance methods are, however, subject to ascertainment and referral bias. Studies utilizing active surveillance to collect all deaths in a defined population, found by administrative diagnostic coding or death certificate review, have found either no identifiable structural abnormality or coronary artery disease (CAD) in the majority of cases of sudden death (5–11).

Despite advances in defining the causes of sudden death and dramatic developments in the ability to screen for genetic diseases and premature atherosclerosis (12–24), recommendations for screening the young, apparently healthy adult have not changed over the past 4 decades.

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Manuscript received November 22, 2010; revised manuscript received December 22, 2010, accepted January 31, 2011.

Although guidelines critically consider the role of electrocardiographic and molecular screening in select cases at elevated risk (i.e., recurrent syncope, family history of premature unexplained sudden death), the widespread utility of these technologies is uncertain (12,14,25).

Military personnel provide a unique opportunity to examine the cause-specific nature of sudden death in an ethnically heterogenous population. Each applicant to the military undergoes a screening questionnaire with rejection for hypertension, known structural heart disease, symptomatic arrhythmia, and most congenital anomalies (8). However, disqualification for cardiac or vascular system abnormalities is very rare, with an annual rate of disqualification of 0.015% in the year 2000 (8). The military population is unique in that the exact number of persons under examination is clearly identifiable; all health care, whether in or outside of military health care systems is captured and documented; and there is established centralization of all autopsy reporting. Active surveillance in health and in death, with routine performance of an autopsy, allows for reduction of case referral bias, as might be seen in high-profile cases with disproportionate media attention. We describe the leading causes of death in this active surveillance population.

## Methods

The patient population included all uniformed personnel from the Department of Defense. Anyone dying while on active duty was included, from initial entry (i.e., recruits) and those throughout active service, but excluding retired personnel. All uniformed personnel, whether in a combatant or support role, are required to maintain a level of both physical fitness and weight control throughout active service. The most recent demographics find that the population under surveillance has an average age of 28.2 years and is 84.0% male; and although not recorded before 2003, the most recent accession data identified an entry population that self-reported as 72.7% Caucasian, 15.0% African American, 1.2% Pacific Islander, and 2.6% Asian.

For each death, a detailed report to include autopsy is filed with the Armed Forces Institute of Pathology in accordance with established protocol (26). Although not all autopsies were performed at the Armed Forces Institute of Pathology, in Washington, DC, the Office of the Armed Forces Medical Examiner system appoints Regional Medical Examiners, board certified in forensic examination by the American Board of Pathology, to serve as worldwide consultants. Nontraumatic deaths were identified through the Department of Defense mortality registry. Cases were eligible for review if they were categorized as sudden unexplained deaths (SUD) or deaths due to the following causes: cardiac, exertional heat illness, vascular, asthma, and all exercise-related deaths not elsewhere classified. Demographic data and details surrounding the circumstances of the fatal incident were obtained from the pathology reports, reports from the criminal investigative division, and available antemortem medical records.

**Abbreviations and Acronyms**

**ASCAD** = atherosclerotic coronary artery disease

**CAD** = coronary artery disease

**SCD** = sudden cardiac death(s)

**SUD** = sudden unexplained death(s)

The records from each case which met the inclusion criteria were assembled and reviewed by the authors. Adjudication of each case by at least 3 authors was performed, and a final determination was made as to clinical cause of death. In no case was there exclusion of a case due to disagreement as to characteristics and etiology of death. Sudden death was defined as an event resulting in death or terminal life support within 1 h of collapse, or an unwitnessed but unexpected death in the absence of known or suspected condition that may predispose to terminal illness. Deaths were defined as cardiac in origin if there was autopsy confirmed heart disease with clinical circumstances consistent with a potential cardiac etiology of death (excluding, for example, incidental cardiac disease in a patient who experienced traumatic death). SUD was defined as any sudden death unexplained by pre-existing disease and without identifiable cause on post-mortem examination.

Specific cardiac causes of sudden death were defined as follows: atherosclerotic coronary artery disease (ASCAD) was considered the cause when gross pathologic and/or histopathologic findings indicated an acute or recent myocardial infarction or occlusive ASCAD. Hypertrophic cardiomyopathy was based on gross pathologic and histologic findings consistent with the diagnosis (27,28), to include nondilated left ventricular hypertrophy, in the absence of coexistent disease that could cause in magnitude of hypertrophy evident. Myocarditis was based on histopathologic diagnosis of inflammatory infiltrates in accordance with Dallas criteria (29). Dilated cardiomyopathy was based on left ventricular dilation in the absence of histologic changes consistent with an inflammatory cardiac condition and in the absence of CAD. Anomalous coronary arteries were considered causative when specific anomalies known to be associated with sudden death were noted on autopsy or a coronary anomaly was the only finding. Those anomalies felt to be associated with sudden death included any anomalous left main coronary artery with take-off from the right coronary cusp and a course between the pulmonary artery and aorta, anomalous right coronary artery with oblique take-off, and regional acute or chronic corresponding regional perfusion defect. Separate coronary ostia, cloacal left main coronary artery, and anomalous circumflex off the right coronary cusp were not considered to be causative of sudden death. Hypertensive cardiomyopathy was based on left ventricular hypertrophy or dilation in the setting of known clinical hypertension. Arrhythmogenic right ventricular dysplasia was based on gross pathologic and histologic findings focusing on structural and histologic manifestations (30). Ischemic heart disease was attributed as the cause of