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IMPORTANCE OF SUDDEN CARDIAC DEATH SCREENING IN YOUNG ATHLETES: PLACE AND ROLE OF TELEMEDICINE ELECTROCARDIOGRAPHY

ZNAČAJ SKRININGA IZNENADNE SRČANE SMRTI KOD MLADIH SPORTISTA: MESTO I ULOGA TELEMEDICINSKE ELEKTROKARDIOGRAFIJE

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Abstract

Young athletes with clinically silent cardiovascular disorders are at increased risk of sudden cardiac death (SCD). Hypertrophic cardiomyopathy and coronary artery anomalies have been identified as the commonest causes in most series. Thus, pre participation screening of athletes is of major importance, but there is significant geographic disparity in medical guidelines and recommendations. Effective measures should be focused to reduce the burden of SCD in young athletes. Cost-efficiency and feasibility of 12-lead ECG is being questioned. As an alternative, less expensive telemedicine ECG transmission device can be used as screening tool for the prevention of SCD. This article summarizes the most common causes of SCD in young athletes and evaluates the screening methods used to screen for these conditions.

INTRODUCTION

It is known that sport has several health benefits. Unfortunately, in rare cases, without previous warning signs it might be associated with sudden cardiac death (SCD). Such tragic events assume a high public profile often accusing the medical community to be responsible for failing to implement any prevention measures.

There are different definitions of SCD. The most quoted and competent one is of American college of cardiology, defining SCD as „nontraumatic and unexpected sudden death that may occur from a cardiac arrest, within 6 hours of a previously normal state of health" [(1)].

Epidemiology

Reports indicate increasing frequency of SCD worldwide [(2)], with varying incidence rate between countries 0.6 – 2.6/100 000, estimated to be prevalent in older athletes (20-35 years of age) compared to adolescents, with 100 times higher risk. Males are 2–20 times at greater risk than females. Male African-American athletes, and basketball players are identified as subgroups with a higher risk of SCD, with incidence rate up to 33.3/100 000. As risky sports for SCD running, tennis, rugby, and swimming gymnastics have been identified[(3)]. Literature review indicate controversial data regarding incidence rate of SCD in athletes versus nonathletes. Reports of Toresdahl[(4)] and Corrado[(5)] showed that SCD is 3–5fold higher in athletes than in nonathletes. Contrary, in Italy after implementing compulsory screening in athletes, the incidence of SCD become lower in this group (0.5/100 000 in athletes vs 0.8/100 000 in nonathletes) [(6)]. Report of Harmon in United States has showed no significant difference between these two subgroups (2.6/100 000 in athletes vs 2.5/100 000 in nonathletes)[(7)]. Extreme opposition to these data come from Danish study, pointing the facts

that athletes have 3.3-fold lower risk for SCD than nonathletes [8]. We would like to point out, that is very difficult to draw any precise conclusion because of the small number of reported cases of SCD. However, according to literature, it can be assumed that athletes are generally in higher risk of SCD (3–5-fold) than nonathletes [9].

Causes of sudden cardiac death in athletes

There are several ways to classify the causes of SCD in athletes depending on age (below and over 35 years), heritage (congenital or acquired), or by the action of the force (nontraumatic vs traumatic). In athletes under 35 years of age, predominate congenital conditions with hypertrophic cardiomyopathy (HCM) as the single most common cause of athlete deaths. HCM and "possible HCM" together are responsible for approximately one third to 46% of all the cases of SCD, followed by coronary artery anomalies, particularly aberrant coronary arteries (~20%). Other causes include arrhythmogenic right ventricular dysplasia, myocarditis, channelopathies, valvular hearth diseases (bi-leaflet mitral valve prolapse syndrome) and aortopathies (aortic aneurysm) that could be associated with Marfan syndrome. Also, acquired conditions responsible for causing SCD are substance misuse and environmental factors influence (i.e. hypothermia or hyperthermia) [10-12]. In athletes older than 35, acquired atherosclerotic coronary artery disease is the leading cause of SCD [13]. *Commotio cordis* deserves mention, because it has been recognized as the most common traumatic cause of SCD. In contact sports such as baseball, ice hockey, football or lacrosse, lower frequency blow to the chest by projectile used to play the game or from physical contact between competitors induce transfer of kinetic energy, causing no structural damage. In electrically vulnerable period of cardiac cycle (ventricular repolarization) within a narrow window of 10 to 20 ms on the upstroke of the T wave, just before its peak, such energy induces ventricular fibrillation and cardiac arrest [14].

Prevention strategies

A number of prevention strategies have been developed in order to identify those who are at risk for SCD. Nowadays, there are two major approaches to reducing the risk of SCD in athletes. Primary prevention as preparticipation evaluation for heart diseases and management of any such diseases to substantially reduce the risk of SCD. While, secondary prevention includes early external defibrillation by use of automated external defibrillators (AED) [15].

Scientific committees of leading organizations such as the American College of Cardiology, the American Heart Association (AHA), the European Society of Cardiology (ESC), International Olympic Committee (IOC) Medical Commission, Fédération Internationale de Football Association (FIFA) and others recommend preparticipation evaluation. More less they are very similar and they are based on taking a personal and family history, physical examination, and 12 lead ECG [3]. Questions address primarily symptoms relating to cardiac disease should be focused on ominous symptoms such as exercise-related syncope, exertional dyspnea or chest pain, shortness of breath, palpitation, and abnormal dyspnea or fatigue. Actually, AHA short questionnaire is composed of 14 items [16], while IOC and ESC questionnaire are composed of 36 items [17]. At least one positive response is sufficient to referral for cardiovascular examination. Family history should be focused on unexpected SCD in at least one first-degree relative before the age of 50, inherited cardiomyopathies, Marfan syndrome, and severe arrhythmias [18]. Physical examination should be focused on recognition of Marfan syndrome characteristics, auscultation of the heart in both supine and standing positions, palpation of femoral pulses and bilateral brachial blood pressure. Pathological findings such as diastolic or systolic hearth murmurs > 2/6, fixed by respiration and reinforced after exercise, midsystolic click, irregular heart rhythm, and/or asymmetric artery pulses especially between arms and legs require referral to cardiologist. It should be noted that systolic murmur is indicative for a left ventricular outflow obstruction in HCM. It is audible at rest in 25% of cases, even to 50% in the standing position or by performing Valsalva maneuver [3].

ECG as a screening tool and use of wireless ECG transmission device

The use of ECG as a screening strategy is debated, due to several causes including costs, false-positive results and low specificity to differentiate physiological to pathological variants in athlete's heart. To overcome these problems, several guidelines and expert consensus statements have been designed to help doctors differentiate between potentially disease related and benign ECG alterations in athletes. Such documents are the Seattle criteria and the European Society of Cardiology criteria [19, 20]. According to these recommendations ECG changes such as sinus bradycardia, first-degree AV block, early repolarization, incomplete right bundle branch block and pure increase of QRS voltages, are common finding in up to 80% of trained athletes as consequences of the physiologic cardiovascular adaptation to sustained physical exertion, requiring no additional evaluation. On the other hand, uncommon ECG abnormalities such as ST-segment and T-wave repolarization abnormalities, pathological Q waves, intraventricular conduction defects, and ventricular arrhythmias should be regarded as an expression of a possible underlying cardiomyopathies and channelopathies, with an inherent increased risk of SCD [19]. As an argument against screening programs that include ECG, the cost-benefit ratio has been used. In the often-quoted Italian study, 33 000 athletes would need to be screened to save one life at a cost per life saved of 1185 000 € (1 320 000$)[21]. Despite this consideration, the sensitivity of the history and physical examination in detecting the presence of the most common causes of SCD are 30%. But with the addition of ECG testing alone, the sensitivity of screening is increased to 70% [22]. ESC and IOC recommends the addition of 12-lead ECG in the initial screening stages, while AHA recommendation does not include universal 12-lead ECG recordings. Curiously, the World Health Organization has designated the Wilson and Jungner criteria, trying to expand preparticipation screening programs not only to athletes, but to all school children [12].

Wireless ECG transmission devices could be good substitution for standard 12-lead ECG, making screening feasi-

ble for the prevention of SCD. They monitor cardiac activity in a real time and have an invaluable significance as event recorder. Advantages of such devices are numerous such as

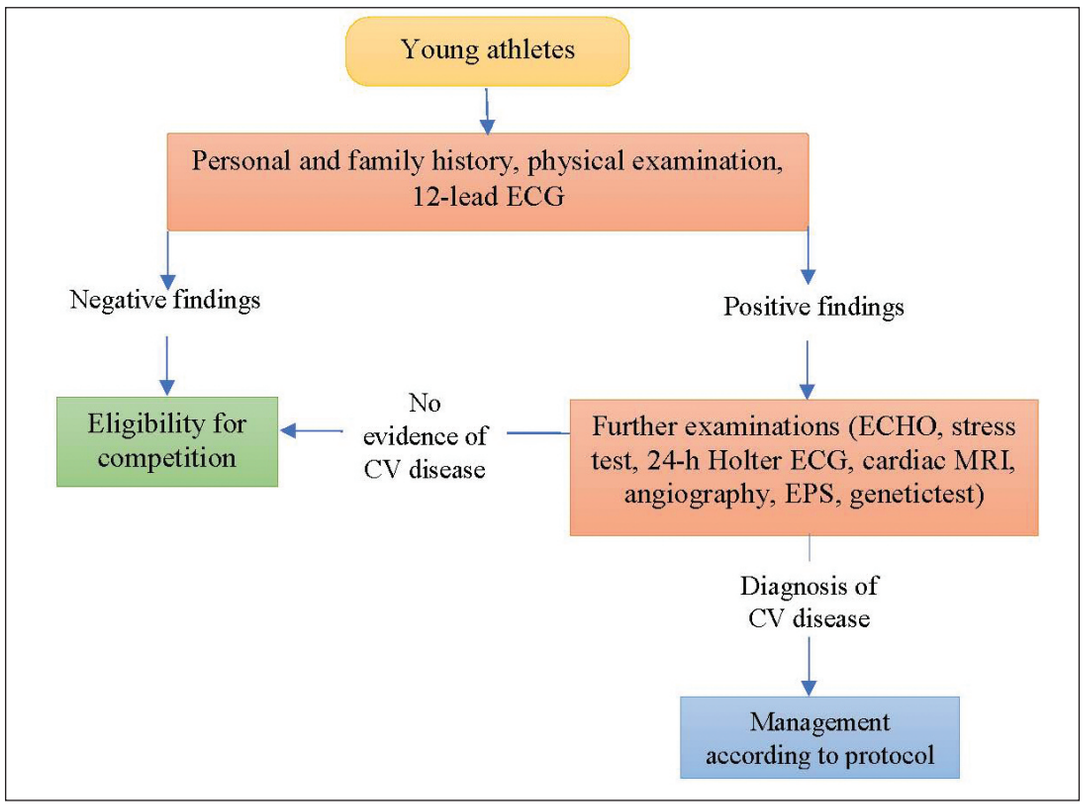

Figure 1. *Protocol of preparticipation screening recommended by the European Society of Cardiology. ECHO-echocardiography, CV-cardiovascular, EPS-electrophysiologic study. Adopted and modified from the study by Corrado et al.* [25]

lower price, does not require strips, therefore cheaper maintenance, wider and simpler usage, possibility of attenuation of artifacts, and more accurate diagnosis in the case of a good software algorithm, without requiring expert knowledge or additional medical education. Overall significantly reducing costs. In Italian pilot study, wireless 9-lead ECG showed significant correlations with a conventional 12-lead ECG in screening of young competitive athletes for the prevention of SCD [23]. An observational retrospective study, also in Italy, which included 13 016 high school students (16-19 years of age), for SCD screening in general population by using a telecardiology device. A total of 24% of students had at last some of 14 alterations in ECG such as ventricular ectopic beats, atrioventricular block, Brugada-like electrocardiogram pattern, left anterior/posterior fascicular block, left/right ventricular hypertrophy, long/short QT interval, left atrial enlargement, right atrial enlargement, short PQ interval, and ventricular pre-excitation Wolff–Parkinson–White syndrome. Those data were in consistence to family history for cardiovascular disease. Analysis also provide economic sustainability of the ECG screening strategy with telemedicine ECG devices [24].

In any case of suspicious findings in the history or physical examination or an abnormal ECG, athlete should be referred to cardiologist for additional investigations (echocardiogram, exercise testing, 24-hour ECG Holter monitoring, cardiac MRI, contrast angiography or additional electrophysiological study) (Figure 1). Meanwhile, patients should be advised against playing any competitive or strenuous sports [25].

CONCLUSION

Sudden cardiac death is an extremely rare, unexpected, tragic event with large impact on society. In younger athletes, SCD mostly occurs due to inherited diseases, such as HCM and coronary artery anomalies as two most common causes. While in older athletes, coronary artery disease is primary cause of SCD. Regardless of the recommendations of the Europeans or Americans associations, goals of preparticipation screening programs are to identify athletes at high risk of SCD and to refer them for additional cardiovascular investigations. Nevertheless, the perfect screening instrument is currently not available and usage of 12-lead ECG is still the subject of ongoing debate. However, no matter cost-effectiveness, a moral and ethical principles of physicians obligate them to provide the most efficient and prudent manner available. The usage of updated ECG criteria will improve ECG accuracy in the evaluation of trained athletes. The use of novel technologies, such as wireless ECG transmission devices, can be a good alternative to the standard ECG, leading to considerable reduction of costs required to achieve preparticipation mass screening programs. But, further studies are needed to test their utility and cost-effectiveness. Until then, increasing awareness about SCD, implementing programs of cardiac arrest management as training in cardiopulmonary resuscitation at a community level, placing more defibrillators in sporting clubs and schools and using in the field AED are some important steps in helping to prevent events of SCD in athletes.

Sažetak

Mladi sportisti sa klinički inaparentnim kardiovaskularnim oboljenjima u većem su riziku od nastanka iznenadne srčane smrti (ISS). U većini serija slučajeva, kao najčešći uzroci utvrđeni su hipertrofična kardiomiopatija i anomalije koronarnih krvnih sudova. Stoga je od posebnog značaja sprovođenje skrining kod sportista, mada postoji značajan geografski disparitet u medicinskim smernicama i preporukama ovih programa. Efikasne mere trebaju da su usmerene na smanjenje pojave ISS kod mladih sportista. Dovodi se u pitanje isplativost i izvodljivost 12-kanalnog EKG. Kao alternativa, jeftiniji prenosivi telemedicinski EKG uređaji se mogu koristiti kao skrining alat za prevenciju ISS. Ovaj članak rezimira najčešće uzroke nastanka ISS kod mladih sportista i procenjuje metode skrininga koje se koriste za procenu ovih stanja.

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