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Review article

Electrocardiographic changes in patients with hypertrophic cardiomyopathy: Relevance for athletic screening

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Abstract Hypertrophic cardiomyopathy is one of the most prevalent inherited cardimyopathies and according to the US data is the leading cause of sudden cardiac death in athletes. Athletes with HCM are asymptomatic in majority of cases and have normal physical phindings, however over 90% of them have abnormal ECG, so it is important to recognize these ECG patterns.

Key words hypertrophic cardiomyopathy, electrocardiogram, athletes

Hypertrophic cardiomyopathy (HCM) is one of the most prevalent inherited cardiomyopathies in general population with an incidence of 1:500[1], that is responsible for 5% of all sudden cardiac deaths (SCD)[2]. In elite athletes the prevalence of the disease is significantly lower 1:1500[3], however according to US data it is responsible for more than 1/3 of all SCD in this population[4]. HCM was cause of death in 11% of British atheltes[5]. Overall, these data underscore the importance of screening for HCM in athletes.

Athletic screening comprises of detailed history, including history of sudden cardiac death in family members, physical examination and 12 leads electrocardiogram (ECG). Sympotms suggestive of HCM are fatique, dyspnea, anginal chest pain and syncope. However, in some patients, the first presentation of the disease is SCD.

Typical physical finding of systolic murmer over left sternal border is present in only 21% of patients with known disease (4). On the other hand over 90% of patients with HCM have pathological ECG.

Electrocardiographic changes in patients with hypertrophic cardiomyopathy

According to the Italian experience, introduction of 12-lead ECG in athletic screening resulted in significant decrease in SCD in this population, predominantly due to the identification of patients with congenital cardiomyopathies and channelopathies.

Correct interpretation of ECG enables identification of the athletes with risk of SCD. However, physicians should be familiar with sport related ECG changes (bradicardia, first degree AV block, etc) in order to avoid further unnecessery investigations.

First official guidelines for ECG interpreation in athletes were published by European Society of Cardiology in 2010[7]. Due to the large amount of published data in the field and expansion of the scientific knowledge in sports cardiology several revisons of ECG interpretation in athletes were published subsequently. The major intention of these revisions was to decrease false positive results, but to maintain adequate sensitivity by correctly differentiating physiological ECG changes in athletes from pathological. In the mixed group of 4297 white and 1208 black athletes, and 103 athletes with known HCM[8], the prevalence of false positive results was 21.5% according to 2010 ESC criteria, 9.6% according to Seatlle criteria[9] and 6.6% based on refined Seatlle criteria[8]. All three criteria identified patients with HCM with sensitivity of 98.1%, suggesting that implementation of revised guidelines resulted in increased specificity with preserved senitivity.

HCM is characterized by different ECG changes such as negative T waves, ST segment depression, pathological Q waves, left bundle branch block, left axis deviation, left atrial enlargement.

Negative T waves are defined as negative T waves more than 1mm in depth in two or more leades except in leads D3, aVR and V1. In patients with confirmed HCM prevalence of negative T waves is 54-62% in white[10,11] and 77% black patients[12]. On the other hand, the prevalence of negative T waves in inferior or/and lateral leads in healthy white athletes is very low (2%)[13], but its prevalence is significantly higher in black athletes 8-10%[12]. Presence of negative T waves in inferior, lateral and inferolateral leads in athletes should always raise suspecion of HCM. Negative T waves in leads V4-V6 are suggestive of apical form of HCM. For the confirmation of apical HCM magnetic resonance imaging is frequently required, since some cases may be missed by transthoracic echocardiography. Deep negative T waves in lateral and inferolateral leads are almost always related to pathological conditions, whreas isolated deep negative T

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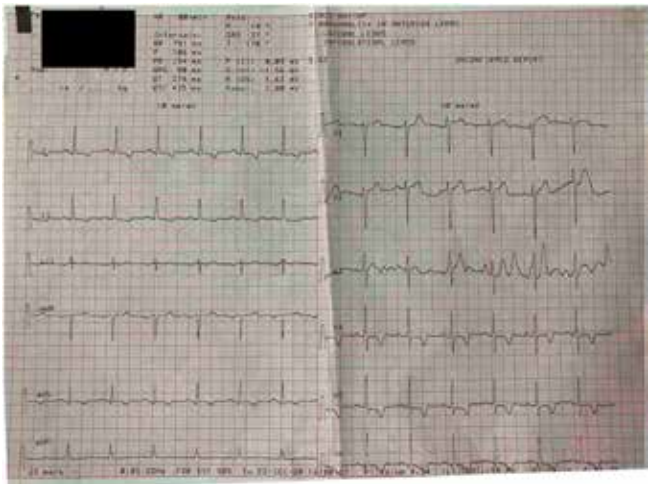

Figure 1. ECG in patient with HCM, note the presence of deep negative T waves predominatly in lateral leads

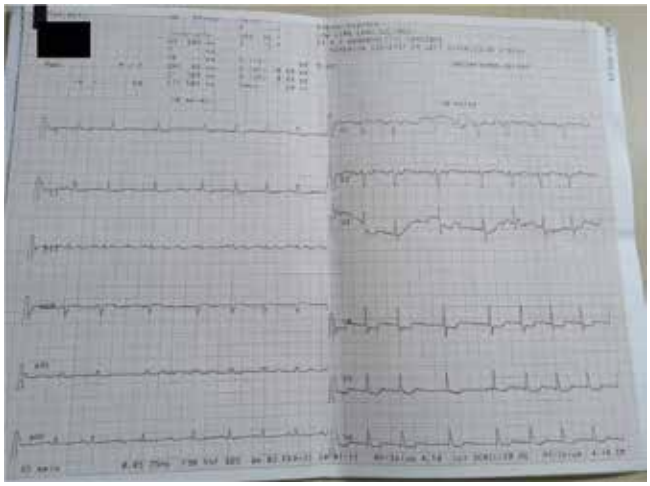

Figure 2. ECG in patient with HCM and atrial flutter. Please note ST segment depression in leads V4-V6 without voltage criteria for LV hypertrophy, and pronounced negative portion of atrial P waves in lead V1

waves in inferior leads are rarely sign of underlying pathological condition, but further workup is also required.

ST segment depression is extremely rare finding in healthy athletes with the prevalence of less than 1%[11,12]. The prevalence of ST segment depression (Figure 2), defined as ST segment depression of more than 0.5mm in two or more leads, is around 50% in patients with HCM[14].

Pathological Q waves are frequent finding in patients with HCM, detected in 42% of asymptomatic patients[15]. Abnormal Q is defined as Q wave of more than 3mm in depth and of more than 40 msec in duration. In the presence of deep narrow Q waves (less than 40 msec in duration), which is common finding in lean highly trained athletes, pathological Q waves are characterized by the Q/R ratio more than 0.25. The presence of pathological Q waves in athletes requires further investigation. Similarly, further work up is required in all the athletes with **complete left bundle branch block** (prevalence of 2% in patients with HCM)[14] or **slow interventricular conduction** (QRS duration more than 140 msec).

Left axis deviation, between -30 to -90 is extremly rare finding in athelets (< 1%)[12,16]. Left atrial enlargement (P wave duration of more than 120 msec in leads I and II with negative portion of P wave in V1 of more than 1mm in depth and ≥ 40 msec in duration in lead V1) is considered to be abnormal in athletes.

Isolated voltage criteria for LV hypertrophy (Lion-Sokolov criteria sum of S wave in V1 and R in V5 or V6 more than > 35mm) is highly prevalent finding in athletes 64%[13,17] and represents increased left ventricular mass due to the physical training. Isolated voltage criteria for LV hypertrohy (without any other ECG changes such as left atrial anlargement, axis deviation) in asyptomatic athletes, with normal physical findings and without history of SCD in family members do not require further investigation. However, isolated voltage criteria for LV hypertrophy can be the only ECG finding in less than 2% of patients with confirmed HCM, but these patients have more benign prognosis with low risk for malignant rhythm disturbances[18].

All athletes with ECG changes suggestive of HCM require diagnosis confirmation by imaging studies including transthoracic echocardiography or/and magnetic resonance imaging. Currently, athletes with confirmed diagnosis are disqualified from further high level training and compatition.

Athletes with pathological ECG but normal imaging studies including magnetic resonance imaging represent challenging cases. These patients could continue training with regular clinical and imaging follow up. Physicians should be aware that electrocardiographic chages preceed morphological changes in patients with cardiomyopathies[18-20].

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Sažetak

Elektrokardiografske promene kod hipertrofične kardiomiopatije: Značaj za skrining sportista

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Hipertrofična kardiomiopatija predstavlja jednu od najčešćih naslednih kardiomiopatija i prema podacima iz SAD vodeći je uzrok naprasne smrti kod mladih sportista. Vrlo česte sportisti sa hipertrofičnom kardiomiopatijom su bez simptoma i sa urednim fizikalnim nalazom. Međutim, patološke promene na 12-kanalnom elektrokardiogramu su prisutne i kod 90% bolesnika sa HCM, tako da je poznavanje elektrokardiografskih promena važno za identifikaciju ovih sportista.

Ključne reči: *hipertrofična kardiomiopatija, elektrokardiogram, sportisti*