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Use of POCUS in cardiovascular screening of young athletes: diagnostic value in the era of international electrocardiographic criteria

POCUS en el reconocimiento cardiológico de deportistas jóvenes: valor diagnóstico en la era de los criterios electrocardiográficos internacionales

To the Editor,

The use of electrocardiographic (ECG) assessment in preparticipation cardiological screening is currently supported by the clinical guidelines due to its ability to detect heart disease, a common cause of sudden cardiac death in athletes younger than 35 years.[1] The 2017 publication of the international criteria for ECG interpretation in athletes[2] defines normal, borderline, and pathological findings, which substantially improved the sensitivity and specificity compared with previous criteria.[3] Despite this, the assessment continues to generate false positives that cause worry in athletes and their relatives and temporarily limit their sporting activity.

Point-of-care ultrasound (POCUS) could improve the diagnostic yield of these electrocardiographic criteria through the use of focused protocols. Their usefulness in detecting structural findings with prognostic value has been demonstrated in several studies.[4]

Our study was designed with the main objective of evaluating the applicability of POCUS in cardiovascular screening programs and its role in determining eligibility for competitive sports if there are pathological ECG findings according to international criteria. To do so, we included a total of 978 athletes from different types of sport, with a mean age of 16.7 ± 3.7 years, mostly soccer players (65%), and mostly male (81%) (table 1). All the athletes were registered with an association, training 3 to 5 days per week and competing at the weekend. Cardiologists specialized in the care of athletes performed the assessment, which included a history, physical examination, resting ECG, and POCUS focusing on the diagnosis of structural heart disease. The POCUS protocol involved measurement in M mode of septal thickness and posterior wall thickness; measurement of the aortic diameter, left atrial diameter, and left ventricular end-diastolic diameter on the parasternal long axis view; measurement of the right ventricular outflow tract diameter and checking the aortic valve and the coronary ostia on the parasternal short axis view, and study of the mitral and aortic valves with Doppler (including mitral filling pattern, septal tissue Doppler, aortic flow continuous Doppler, and color Doppler of both valves), as well as a general cardiac or 4-chamber view. The athletes were classified based on the interpretation of their ECG in line with international criteria. The study was approved by the Hospital IMED Valencia ethics committee, and all the athletes gave signed informed consent.

Pathological ECG criteria were found in 35 athletes (3.6% of the total): 27 due to negative T waves or ST-segment depression, 6 due to the presence of 2 or more ectopics on ECG, 1 due to prolonged QT interval, and 1 due to pre-excitation syndrome (table 2). POCUS during the screening visit, estimated to take < 5 minutes, showed an excellent diagnostic yield in the assessment of repolarization abnormalities classified as pathological according to the international criteria. This allowed significant structural heart disease to be ruled out in 25 of the 27 athletes with negative T waves (in this context, a reduction in the rate of ECG false positives of up to 92.5%). In the 2 remaining athletes, a suspected diagnosis of hypertrophic cardiomyopathy was reached. In the first case, this was on the basis of septal hypertrophy with a maximum midapical thickness of 15 mm in the presence of negative T waves on ECG in the inferior leads and V_5-V_6. In the second case, it was on the basis of negative T waves with ST-segment depression in III and V_4-V_6, a lateral hypertrabeculation pattern with spongiform appearance on POCUS, and cardiac magnetic resonance showing a nonobstructive hypertrophic cardiomyopathy pattern.

In the patients with the other pathological findings described (long QT, ventricular ectopics and pre-excitation syndrome), POCUS did not lead to changes in the impression from the electrocardiographic assessment, and therefore eligibility was delayed due to the need for other diagnostic tests.

Therefore, POCUS was especially useful in patients with repolarization abnormalities on ECG, present in 3% of the sample and in line with previous studies.[5] In addition, and although it was not the aim of this study, it was able to detect other structural abnormalities not detected on ECG, such as coronary anomalies (we were able to confirm the normal position of the ostia in more than 90% of the athletes) or common valvulopathies such as bicuspid aortic valve or mitral valve prolapse. Although these conditions rarely affect prognosis in athletes, their early detection enables regular cardiological follow-up and treatment if required.

The limitations of this study include the sample size, the high percentage of male soccer players, and the analysis of results from a single medical center.

Despite these limitations, we can conclude that POCUS as part of the cardiovascular screening of young athletes is a fast and simple technique that allows exclusion of the presence of significant structural heart disease in individuals with repolarization abnormalities that are classified as pathological according to international ECG interpretation criteria.

Table 1
General characteristics of the study population: demographic, electrocardiographic, and echocardiographic variables

Total sample: 978 athletes			
Demographic parameters			
Age, y			16.7 ± 3.7
Male			782 (81)
Race/ethnicity			
White/Caucasian			889 (91)
Black/African-American			64 (6)
Asian			25 (3)
Sport			
Soccer			636 (65)
Tennis			111 (11)
Indoor soccer			99 (10)
Basketball			42 (4)
Other			90 (9)
Investigations			
Electrocardiogram		Echocardiogram	
Heart rate, bpm	61.2 ± 13.6	Septal thickness, mm	9.4 ± 1.5
Axis,°	74.2 ± 24.0	LV end-diastolic diameter, mm	48.4 ± 4.2
QRS width, ms	91.1 ± 9.7	LV end-systolic diameter, mm	25.3 ± 3.4
Corrected QT interval, ms	399.2 ± 21.9	Posterior wall thickness, mm	9.7 ± 1.6
Right bundle branch block	364 (27)	LVEF, %	66.6 ± 4.2
Sokolow-Lyon index, mm	36.1 ± 9.3	Indexed LV mass, g/m^2	96.2 ± 20.8

LV, left ventricle; LVEF, left ventricular ejection fraction.

Table 2
Pathological ECG parameters according to international criteria

ECG parameter	Athletes (% of the total)	POCUS ruled out structural heart disease (%)	Comments
All pathological criteria	35 (3.6)	25 (71)	
Inverted T waves/ST depression	27 (2.8)	25 (93)	2 athletes with a diagnosis of hypertrophic cardiomyopathy (cardiac magnetic resonance, genetic study)
Ventricular ectopics (2/+)	6 (0.6)	0	Cardiological follow-up (Holter ECG)
Prolonged QT interval	1 (0.1)	0	Outpatient follow-up
Ventricular preexcitation	1 (0.1)	0	Electrophysiology study and successful ablation

ECG, electrocardiogram; POCUS, point-of-care ultrasound.

Its incorporation into cardiovascular screening programs could significantly reduce the false positive rate from ECG and accelerate eligibility for sports in cases of certain pathological ECG findings with suspected cardiomyopathy.

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AUTHORS' CONTRIBUTIONS

All authors contributed substantially to the conception and design of the study and the data collection, analysis, and interpretation. They also all participated in the writing and critical review of the manuscript for its final approval.

CONFLICTS OF INTEREST

None.

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Microvascular dysfunction and invasive absolute coronary flow after percutaneous coronary intervention for a chronic total occlusion. The FLOW-CTO study

Disfunción microvascular y flujo coronario absoluto invasivo tras intervención coronaria percutánea de oclusión total crónica. Estudio FLOW-CTO

To the Editor,

Percutaneous coronary intervention (PCI) of chronic total occlusion (CTO) is a demanding situation. This condition causes abnormalities in the vascular bed distal to the lesion and in the related microvasculature. Percutaneous treatment of CTO improves the patient's quality of life and reduces angina.[1] Positron emission tomography scans have shown an improvement in myocardial blood flow and coronary flow reserve (CFR) after CTO PCI.[2] However, improvement is not immediate and can take weeks or months.[3]

The Microvascular Coronary Resistance and Absolute Coronary Flow in Patients With Percutaneous Intervention of a Chronic Total Occlusion study (FLOW-CTO; NCT05197361) was designed to evaluate the trend over time of microvascular resistance and absolute coronary flow after CTO PCI. The study was conducted at 4 Spanish sites with consecutive patients who underwent a functional study immediately after the procedure and at 6 months and measured the fractional flow reserve (FFR), CFR, and index of microvascular resistance (IMR). Absolute coronary flow and microvascular resistance were determined by continuous thermodilution during maximum hyperemia induced by serum infusion, as previously described.[4] The procedure was performed using the PressureWire X guidewire (Abbott, United States) and the Coroventis program (CoroFlow Cardiovascular System, Sweden). Microvascular dysfunction was defined as IMR $\geq$ 25 or CFR $<$ 2.0 in the presence of FFR $>$ 0.80. The protocol was approved by the Research Ethics Committee for medications at the coordinating site, and all patients provided written informed consent. The data obtained from the baseline study immediately after CTO PCI are presented for the first 49 patients.

Table 1 lists the clinical, angiographic, and procedure characteristics. Most patients were men, and the mean age was 60 to 69 years. The prevalence of hypertension, dyslipidemia, and diabetes was 71%, 67%, and 41%, respectively. More than half the patients had a history of ischemic heart disease, and 55% had required PCI. The median left ventricular ejection fraction was 55% [interquartile range, 45-60]. A total of 86% of patients had exertional angina, and 14% had a history of heart failure.

The vessel most commonly involved was the right coronary artery (55%), followed by the anterior descending artery (31%). The median Japanese Multicenter CTO Registry (J-CTO) score was 2 points. The most frequently used technique (74%) for PCI was antegrade guidewire upgrade, and the median number of stents

Table 1
Baseline, angiographic, and functional study characteristics

Patients, n	49	*P*
Age, y	62 [56-69]	
Men	44 (90)	
Hypertension	35 (71)	
Dyslipidemia	33 (67)	
Diabetes mellitus	20 (41)	
Insulin-dependent DM	6 (12)	
History of smoking	24 (49)	
Chronic kidney failure (eGFR $<$ 60 mL/min)	5 (10)	
History of ischemic heart disease	29 (59)	
History of AMI	18 (37)	
History of PCI	27 (55)	
History of CABG	2 (4)	
LVEF, %	55 [45-60]	
Exertional angina	42 (86)	
History of heart failure	7 (14)	
Positive ischemia/viability study	29 (59)	
Stress echocardiography	6 (12)	
SPECT	10 (20)	
Cardiac magnetic resonance	13 (27)	
Normal regional contractility + symptoms of myocardial ischemia	20 (41)	
Vessels with CTO		
Anterior descending artery	15 (31)	
Circumflex artery	7 (14)	
Right coronary artery	27 (55)	
Main collateral vessel		
Anterior descending artery	29 (59)	
Circumflex artery	6 (12)	
Right coronary artery	14 (29)	
J-CTO score	2 [1-2]	
PCI-CTO technique		
Antegrade guidewire upgrade	36 (74)	
Retrograde guidewire upgrade	8 (16)	
Antegrade dissection and re-entry	4 (8)	
Retrograde dissection and re-entry	1 (2)	
Number of stents	2 [1-3]	
Total length of stents, mm	59 $\pm$ 25	
Residual stenosis, %	8 $\pm$ 4	
Scope time, min	37 [29-45]	
Contrast administered, mL	280 [220-350]	
Collateral persistence after PCI		
Absent	29 (59)	
Present	13 (27)	
Not evaluated	7 (14)	