CARDIOLOGIE TUNISIENNE

ARTICLE ORIGINAL

The contribution of echocardiography to the cardiovascular assessment for military aptitude

La contribution de l'échocardiographie à l'évaluation cardiovasculaire de l'aptitude militaire

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Summary

Introduction: Several studies have demonstrated that right ventricular (RV) echocardiographic parameters predict prognosis in heart failure (HF), but none have specified their prognostic value in acute HF (AHF) with reduced ejection fraction ≤ 40%.

Aim: To demonstrate the prognostic value of RV echocardiographic parameters among patients with AHF and reduced ejection fraction ≤ 40%.

Methods: This was a prospective, descriptive, monocentric study conducted over a period of 24 months. We enrolled 56 patients who presented with AHF and a reduced LVEF ≤ 40%.

All patients included underwent an echocardiography study of the RV function: RV free wall strain (RVFWS), RV fractional area change (RV FAC), tricuspid annular plane systolic excursion and Peak systolic velocity of tricuspid annulus.

At the end of follow-up, cardiovascular mortality and rehospitalization rate for HF were studied.

Results: The average age of our population was 63 ±10 years. During follow-up, rehospitalization for HF and cardiovascular mortality were observed respectively in 57% and 20% of cases. In the multivariate analysis, only RVFWS with a cutoff value of -18.5% was an independent predictor for rehospitalization (95% CI 0.752-0.977; p=0.021). RV FAC with a cutoff value of 22.5% was an independent predictor for cardiovascular mortality (95% CI 1.019-2.673; p=0.042).

Conclusion: RVFWS and RV FAC seem to be strong predictors of prognosis in patients with AHF and reduced ejection fraction.

Keywords

Acute heart failure; cardiovascular mortality; rehospitalization; echocardiography

Résumé

Introduction : Plusieurs études ont démontré que les paramètres échocardiographiques du ventricule droit (VD) prédisent le pronostic dans l'insuffisance cardiaque (IC), mais aucune n'a spécifié leur valeur pronostique dans l'IC aigue (ICA) avec une fraction d'éjection réduite ≤ 40%.

Objectif : Démontrer la valeur pronostique des paramètres échocardiographiques du VD chez les patients présentant une ICA et une fraction d'éjection réduite ≤ 40%.

Méthodes : Il s'agissait d'une étude prospective, descriptive, monocentrique réalisée sur une période de 24 mois, incluant 56 patients présentant une ICA et une FEVG réduite ≤ 40%. Tous les patients ont eu une évaluation échocardiographique de la fonction VD : le strain de la paroi libre du VD (StrainVD), la fraction de raccourcissement du VD (FRVD), l'excursion systolique du plan annulaire tricuspidien et la vélocité systolique maximale de l'anneau tricuspidien.

À la fin du suivi, la mortalité cardiovasculaire et le taux de réhospitalisation pour IC ont été étudiés.

Résultats : L'âge moyen de notre population était de 63 ±10 ans. Au cours du suivi, la réhospitalisation pour IC et la mortalité cardiovasculaire ont été observées respectivement dans 57% et 20% des cas. En analyse multivariée, seul le Strain VD avec une valeur seuil de -18,5% était un prédicteur indépendant de réhospitalisation (IC 95% 0,752-0,977; p=0,021). La FRVD avec une valeur seuil de 22,5% était un prédicteur indépendant de la mortalité cardiovasculaire (IC 95% 1,019-2,673; p=0,042).

Conclusion : Le Strain VD et la FRVD semblent être de forts prédicteurs du pronostic chez les patients présentant une ICA avec une fraction d'éjection réduite.

Mots-clés

Insuffisance cardiaque aigue ; mortalité cardiovasculaire ; réhospitalisation ; échocardiographie

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INTRODUCTION

The incidence of sudden cardiac death (SCD) in athletes varies widely, reflecting the demographic diversity of the groups studied.

Factors such as age, sex, ethnicity, and the specific sport played are crucial in determining the level of risk.

Moreover, there is no universally agreed-upon definition of "athlete," with studies interpreting this term differently depending on the intensity, type, and frequency of exercise involved.

Reliable data on the incidence of sudden death in sports come from a 10-year review of the National Collegiate Athletic Association (NCAA) database, which includes athletes aged 17 to 24 years in the United States. In this cohort, SCD was the leading medical cause of death, with an incidence rate of 1.9 per 100,000 athlete-years [1]

SCD in young athletes (<35 years old) is attributed to a heterogeneous group of cardiac disorders, with inherited cardiac conditions predominating in this age group. While autopsy may identify structural heart abnormalities, a substantial proportion of cases reveal a structurally normal heart, suggestive of sudden arrhythmic death syndrome (SADS), in which a primary electrical disorder is considered the most likely etiology.[2,3]

Hypertrophic cardiomyopathy (HCM) has been identified as the cause of sudden cardiac death (SCD) in approximately 2% to 36% of athletes, depending on the cohort studied [4–6], with some studies from the United States indicating it as the predominant cause of SCD in young athletes. [6]

SCD in athletes may be prevented through cardiac screening in apparently healthy individuals.

The American Heart Association (AHA)/American College of Cardiology (ACC) and the European Society of Cardiology (ESC) recommend preparticipation cardiovascular screening to identify athletes at high risk of sudden cardiac death (SCD)[7,8].

However, there remains no global consensus regarding the optimal strategy for cardiac screening, with significant variability across countries, sports governing bodies, and levels of competition.

Both the American and European guidelines emphasize the importance of a detailed medical history and physical examination as core components of the screening process [7,8]

While the ESC advocates for routine 12-lead electrocardiogram (ECG) screening, the AHA/ACC guidelines prioritize history-taking and physical examination, without recommending routine ECG use.

The AHA 14-point screening approach has demonstrated low sensitivity, as most athletes harboring potentially serious cardiac conditions are asymptomatic and exhibit no abnormal physical findings [9].

The ECG remains a valuable tool for detecting primary electrical abnormalities, such as Wolff-Parkinson-White syndrome and prolonged QT intervals, and it is well established that the majority of individuals with cardiomyopathies demonstrate abnormal ECG findings.

Although some sports organizations supplement ECG screening with echocardiography, the additional diagnostic yield in athletes with a normal ECG, as well as the cost-effectiveness of this strategy, remains uncertain.

The aim of this study is to evaluate the diagnostic yield and clinical relevance of transthoracic echocardiography (TTE) in the cardiovascular assessment of military candidates.

By comparing clinical examination, ECG findings, and echocardiographic results, we seek to determine the degree of concordance between these modalities and to define specific indications for the use of TTE, with the goal of optimizing screening strategies while minimizing unnecessary investigations.

PATIENTS AND METHOD

This is a retrospective cross-sectional epidemiological study conducted at the Tunis Military Hospital between November 2020 and November 2021.

146 patients were enrolled. The primary inclusion criteria was age ≥18 years and referral to the cardiology outpatient clinic for a military aptitude evaluation. Patients who did not undergo TTE after the clinical examination and were subsequently lost to follow-up were excluded from the study.

Medical history, as well as clinical, biological, and echocardiographic data, were collected for all participants.

RESULTS

146 patients were enrolled. The mean age was 25 ± 7 years (range: 18–56 years), with a marked male predominance (98%).

At the end of the cardiovascular evaluation, 84.2% of participants were considered eligible for physical activity.

In our cohort, the most prevalent cardiovascular risk factor was smoking (15.1%), while hypertension and diabetes were each observed in 1.4% of participants, and dyslipidemia in 0.7%.

Out of the total cohort, 123 candidates (84.25%) showed no evidence of functional or structural cardiac abnormalities and were therefore deemed fit for physical activity. In contrast, 23 candidates (15.75%) were classified as unfit for military service based on the findings of their cardiovascular assessment. Among these, 20 were diagnosed with underlying cardiac pathologies, including:

- Complete situs inversus: 1 case
- Perimembranous ventricular septal defect (VSD): 3 cases
- Persistent ductus arteriosus (PDA): 1 case
- Mitral regurgitation: 9 cases
- Aortic regurgitation: 1 case
- Tricuspid regurgitation: 3 cases
- Segmental wall motion abnormality: 1 case
- Left ventricular hypertrophy with myocardial «sparkling» appearance (suggestive of infiltrative disease): 1 case

The most common reasons for consultation were detailed in figure 1.

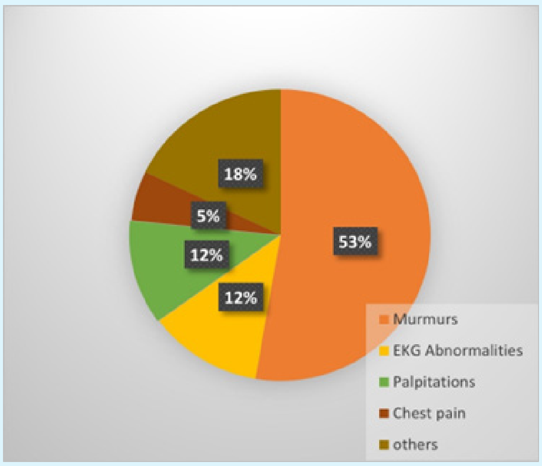

Figure 1. common reasons of consultation

The remaining 3 were considered unfit due to non-structural but clinically significant conditions: two cases of severe hypertension and one case of exertional angina related to a myocardial bridging.

The candidates were referred to our cardiology clinic after an initial primary screening. The most frequent referral indications were: a heart murmur detected during cardiac auscultation (53%), the identification of ECG abnormalities (12%), and, in the remaining cases, the presentation of symptoms such as palpitations or chest pain.

The analysis of the relationship between cardiac auscultation findings and the detection of valvular abnormalities by echocardiography revealed a significant discordance. Indeed, 71.6% (three-quarters) of patients with a heart murmur on auscultation had a normal transthoracic echocardiogram (TTE).

Furthermore, the relationship between electrocardiographic abnormalities (e.g., right bundle branch block [RBBB], left bundle branch block [LBBB], premature ventricular contractions [PVCs], and left ventricular hypertrophy [LVH]) and TTE findings did not demonstrate a statistically significant association ($p = 0.622$).

By combining physical examination data, ECG findings, and chest radiography, we observed that nearly three-quarters (73%) of patients with an abnormal initial assessment had a normal TTE.

In contrast, approximately 10% of patients with a pathological TTE exhibited a strictly normal clinical examination.

DISCUSSION

Our findings highlight the limited concordance between clinical screening tools—such as auscultation and electrocardiography (ECG)—and TTE, and 10% of patients had a pathological TTE with a normal clinical examination.

It has been reported that athletes have a 6.8-fold increased risk of sudden cardiac death (SCD) compared with non-athletes of the same age, related to cardiac pathologies, which in about 90% of cases could theoretically be diagnosed through preparticipation screening.[10,11]

In athletes aged < 35, the majority of sudden cardiac death (SCD) cases are attributed to inherited cardiac disorders. These include hypertrophic cardiomyopathy (HCM), arrhythmogenic cardiomyopathy (particularly arrhythmogenic right ventricular cardiomyopathy, ARVC), congenital coronary artery anomalies, pre-excitation syndromes, as well as conduction system and ion channelopathies such as long QT syndrome and Brugada syndrome [4,13]. (figure2)

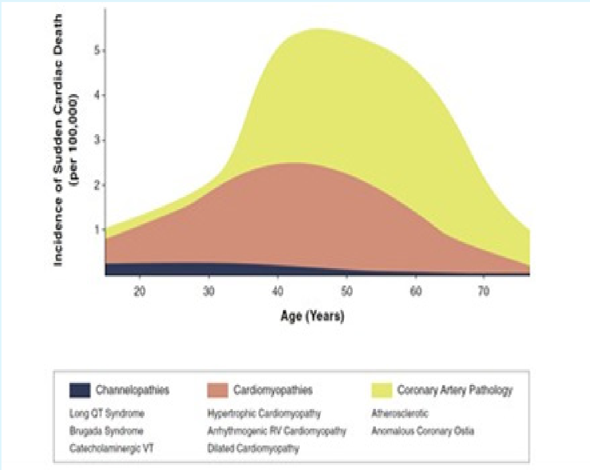

Figure 2. age dependent in incidence and etiology of sudden cardiac death (5)

death (SCD) cases reveal no structural cardiac abnormalities, underscoring the importance of early identification of latent cardiac pathologies [13]. This has led to increased interest in the role of screening tools for preclinical detection. Electrocardiography (ECG) is widely recognized for its sensitivity and specificity in detecting electrical anomalies[14]; however, studies have shown that 9.5%–16.3% of SCD cases involve structural heart disease without corresponding ECG abnormalities[13]. Furthermore, the utility of ECG in athletes remains a topic of debate. Physiological adaptations to exercise can produce ECG changes that are either benign or of uncertain clinical significance, and ethnic variations further complicate interpretation[15].

The athlete's heart is characterized by a higher prevalence of electrocardiographic abnormalities, a proportionate enlargement of both left and right cardiac chambers, increased left ventricular (LV) wall thickness, and enhanced indices of systolic and diastolic function compared to sedentary individuals.[16–18]

So, it is essential for clinicians to adopt an individualized approach when interpreting the cardiovascular evaluation of athletes, as the physiological adaptations of the athlete's heart are influenced by multiple factors, including age, gender, ethnicity, body size and sporting discipline. [19]

Body size significantly influences cardiac dimensions, accounting for approximately 50% of the variability in left ventricular (LV) cavity size and mass among highly trained athletes. [20]

Female athletes demonstrate cardiac adaptations similar in pattern to those observed in their male counterparts; however, these adaptations tend to be less pronounced in absolute terms. Compared to sedentary women, female athletes exhibit modest increases in LV wall thickness and cavity size, as well as moderate enlargement of the right ventricular (RV) and bi-atrial chambers.[21,22]

Ethnicity has emerged as a significant determinant of cardiac adaptation to physical training. Black athletes, in particular, tend to exhibit a higher prevalence of electrocardiographic (ECG) anomalies and more pronounced left ventricular (LV) hypertrophy in response to exercise. [16,22–24] Studies report that up to 40% of Black athletes demonstrate ECG abnormalities, with T-wave inversions present in approximately 20% of this population.[25] Papadakis et al. [16] highlighted that 13% of Black athletes display anterior T-wave inversions in leads V1–V4, often accompanied by ST-segment elevation, a pattern considered characteristic of the 'Black athlete's heart'. Additionally, LV wall thickness greater than 12 mm is observed in 12% of Black athletes, compared to only 2% of White athletes. [16] Differentiating physiological LV hypertrophy from hypertrophic cardiomyopathy (HCM) in Black athletes remains a diagnostic challenge, particularly because their LV cavity sizes are comparable to those of White athletes, while exhibiting a higher wall thickness-to-cavity ratio. In this context, clinical history and repeated blood pressure measurements remain fundamental for the diagnosis. Echocardiography also plays a pivotal role in differentiating physiological adaptations seen in the athlete's heart from pathological hypertensive/hypertrophic heart disease. Key distinguishing features include the pattern and extent of left ventricular (LV) hypertrophy—typically eccentric in athletes versus concentric in hypertensive cardiomyopathy—as well as the potential regression of hypertrophy following detraining. Additional echocardiographic indicators suggestive of pathological remodeling include reduced LV systolic function, evidence of diastolic dysfunction, elevated LV filling pressures, decreased LV e'-velocity, impaired atrial function, and reductions in both LV and left atrial deformation indices. In contrast, physiological adaptations are generally associated with balanced biventricular and biatrial remodeling. [26]

Moreover, Arrhythmogenic cardiomyopathy (AC) is particularly critical to identify, as athletes diagnosed with arrhythmogenic right ventricular cardiomyopathy (ARVC) exhibit up to a 5.4-fold higher relative risk of sudden cardiac death (SCD) compared to non-athletic individuals with AC.[4] Differentiating between physiological remodeling in the athlete's heart and pathological changes seen in AC remains clinically challenging, particularly because a significant proportion of endurance athletes may present with a dilated right ventricle that meets the dimensional criteria for AC. [27] Given that electrocardiographic findings may be subtle or even absent in the early stages of the disease, transthoracic echocardiography (TTE) assumes a pivotal role in the diagnostic work-up. TTE provides detailed structural and functional assessment of both ventricles, enabling the identification of early morphological abnormalities such as localized wall motion anomalies, ventricular dilation, or regional fibrofatty infiltration, which may precede electrical disturbances detectable on ECG. This diagnostic advantage was further illustrated in our study, where nearly 10% of candidates were found to have pathological echocardiographic findings despite having a normal physical examination and electrocardiogram. These results highlight the added value of TTE as a complementary screening tool, particularly in settings where early detection of subclinical cardiomyopathies can significantly impact eligibility and safety in athletic or military populations.

Furthermore, epidemiological studies have shown that athletes have a 79-fold increased relative risk of sudden cardiac death (SCD) due to coronary artery anomalies compared to their non-athletic counterparts.[4] Coronary artery anomalies are often overlooked during routine screening, primarily due to the absence of specific symptoms. However, transthoracic echocardiography offers a valuable diagnostic advantage, as it enables reliable visualization of the origin of the left coronary artery in approximately 99% of cases and the right coronary artery in 96% [28]. Given its non-invasive nature, absence of ionizing radiation, and relatively low cost, echocardiography represents an ideal first-line imaging modality for the detection of such congenital anomalies, particularly in asymptomatic athletic populations at increased risk of sudden cardiac death [29].

These findings emphasize the prognostic significance of early detection of asymptomatic structural cardiac conditions in physically active populations where the risk of adverse outcomes may be elevated and echocardiography has proven to be both effective and cost-efficient in identifying subclinical congenital or acquired structural cardiac abnormalities. So, we propose that a transthoracic echocardiographic could be performed at least once during an athlete's career. In our cohort, 10% of individuals with normal physical and ECG assessments were found to have pathological findings on echocardiography. This highlights the added diagnostic value of echocardiography in detecting structural cardiac abnormalities such as mitral valve prolapse, bicuspid aortic valve, coronary artery anomalies, and aortic dilatation—conditions that may otherwise remain undetected and are associated with a risk of sudden cardiac death (SCD).

CONCLUSION

Sudden cardiac death in young athletes, though rare, remains a devastating event often rooted in underlying structural or inherited cardiac conditions. While initial screening through clinical examination and electrocardiography provides valuable insights, their sensitivity is limited—particularly in the early stages of disease. Our study demonstrates that transthoracic echocardiography (TTE) can uncover clinically silent but potentially life-threatening abnormalities in a significant subset of individuals, with 10% of our cohort presenting pathological findings despite a normal physical exam and ECG. These results underscore the complementary role of TTE in the cardiovascular evaluation for military or athletic aptitude, offering a non-invasive, cost-effective means of enhancing diagnostic accuracy. Incorporating TTE, at least once during the screening process, could significantly improve the early detection of structural cardiac anomalies and contribute to the prevention of SCD in athletic populations.

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