Prevalence of Early Repolarization Patterns in a French Military Population at Low Cardiovascular Risk: Implications for Preventive Medicine

Ulric Vinsonneau, M.D.,* Barbara Pinon, M.D.,* Nicolas Paleiron, M.D.,* Gwenole Rohel, M.D.,* Marie Piquemal, M.D.,* Catherine Desideri-Vaillant, M.D.,* Philippe Castellant, M.D.,† Jérôme Abaléa, M.D.,† Valérie Valls-Bertaut, M.D.,† François Carré, M.D., Ph.D.,‡ Jacques Mansourati, M.D.,† and Philippe Paule, M.D.*

From the *Department of Cardiology, Clermont Tonnerre Hospital of Military Training, 29240 Brest France; †Department of Cardiology, La Cavale Blanche University Hospital, 29200 Brest France; and ‡Department of Cardiology, Ponchaillou University Hospital, 35000 Rennes France

Background: Early repolarization pattern (ERP) associated with a risk of sudden death has recently been described. Very few studies have examined the prevalence of this pattern in a military population characterized by a predominance of young, active male subjects. Therefore, the main objective of this study was to evaluate the prevalence of ERP in a healthy military population free of heart disease but subjected to extreme and potentially arrhythmogenic physical activity.

Methods: This prospective, multicenter study was carried out from November 2010 to November 2011 and included 746 individuals undergoing ECG screening; 466 were men (62.4%) and 280 were women (37.5%). Each ECG was interpreted twice by trained cardiologists.

Results: The total prevalence of ERP was 13.8% (103/746); 16% (46/280) in women and 12% (57/466) in men ($P > 0.05$). It declined with age and the pattern of slurring in inferior location was the most common. Heart rate was significantly lower in military officers with ERP.

Conclusions: ERP was commonly found in this healthy military population. Preventing the risk of sudden death in this population requires systematic ECG screening, medical history analysis and clinical examination to identify symptomatic patients.

Ann Noninvasive Electrocardiol 2013;18(5):436–440

early repolarization; prevalence; military; cardiovascular; preventive medicine

The French military population is a young, predominantly male population that is subjected to specific physical and environmental constraints, which are potentially arrhythmogenic. Among French military officers under the age of 35, the incidence of sudden death (SD) is estimated at 2.5 deaths/year per 100,000¹. Thus, one of the main missions of military cardiologists in 2012 is to detect and manage acquired and congenital heart diseases responsible for SD.

To screen for SD risk, all French military officers undergo regular clinical examinations and systematic ECGs throughout their careers. In case of clinical and electrocardiographic abnormalities suggestive of heart disease, the patient is referred to one of the military hospitals' cardiology department. Prior to 2008, an early repolarization pattern (ERP) on the ECG was considered benign and it did not belong to the etiological spectrum of SD by ventricular fibrillation (VF). This feature, which

Address for correspondence: Dr. Ulric Vinsonneau, Department of Cardiology, Clermont Tonnerre Hospital of Military Training, Brest BP41 BCRM, 29240 Brest Cedex 9, France. Fax: +33-298-437-504; E-mail: ulric.vinsonneau@orange.fr

Funding sources: None declared.

Conflict of Interest: None declared.

©2013 Wiley Periodicals, Inc.
DOI:10.1111/anec.12057

is found in 3–13% of the general population,² was frequently observed in our young and sporty military population, although its exact prevalence was unknown. Its detection did not lead to any complementary cardiovascular exploration or restriction of physical or professional activities. However, several clinical studies published since 2008 have linked the presence of an ERP to the onset of SD due to VF.^{3,4} This revolution in the perception of ERP suddenly raised the issue of how to correctly approach this problem in the practice of preventive medicine, particularly in the absence of established electric or genetic data permitting an accurate assessment of SD risk.

Therefore, the aim of our study was to determine the prevalence of ERP in a specific population under our medical responsibility, to optimize our decisions in terms of aptitude for the armed forces profession.

METHODS

Main Objective

The main objective of the study was to determine the prevalence of ERP as redefined by Haïssaguerre et al.³ in a military population at low cardiovascular risk and free from any heart disease.

Definition of Early Repolarization

Haïssaguerre et al.³ defined early repolarization as a J-point elevation (QRS-ST junction) >1 mm (0.1 mV) from the baseline as a slurring in the transition from the QRS to the ST segment, or a notching, in the inferior (DII, DIII, aVF) and lateral (DI, aVL, V4 à V6) leads, or both (Fig. 1).

Study Population

From November 2010 to November 2011, we prospectively collected the ECGs of military officers incorporated or engaged in French Navy units in Brittany. Inclusion criteria were as follows: Caucasian officers; aged between 17 and 50; involved in at least three hours of sports practice per week; with no history of cardiovascular disease; asymptomatic with normal clinical examination; and with no cardiovascular risk factor (CVRF) such as hypertension (blood pressure >140/90 mmHg), dyslipidemia (total cholesterol >200 mg/dL), diabetes (fasting

Figure 1. Different early repolarization patterns defined according to the criteria of Haïssaguerre et al.³ (slurring, notching, and ST-segment elevation).

glucose >126 mg/dL), active smoking or body mass index (BMI) greater than 30 kg/m². Symptomatic and asymptomatic patients with an abnormality on the ECG, such as a complete or incomplete bundle branch block, atrioventricular block, or atrial fibrillation, were excluded from the study. The ethics committee of the army medical services approved the study.

ECG Interpretation

Twelve-lead ECG recordings were acquired at rest in supine position, and at a speed of 25 mm/s. First, two cardiologists blinded to the identity of the patients interpreted the ECGs separately and manually. To confirm the presence of an ERP, the cardiologists sought a J-point elevation >1 mV in the leads detailed in the definition, and noted its appearance (slurring or notching). The presence or absence of an ST-segment elevation was also recorded.

The presence of an ERP was recorded as ERP+ and the absence of ERP as ERP-. An unclear ERP was recorded as "borderline." Second, the results were compared and the ECGs interpreted once again by two cardiologists working together. The results were validated with the three different interpretations were concordant. In cases of "borderline" appearance, mismatch or lack of consensus, the ECGs were classified as ERP-(ARP-).

Statistical Analysis

Quantitative variables were reported as mean $\pm$ standard deviation. Qualitative variables were reported as percentages. Dichotomous variables were compared using the χ^2 test and continuous variables using Student's t-test (unpaired comparisons of repeated measures only) or an analysis of variance (ANOVA). The level of significance was set at 5% ($P < 0.05$).

RESULTS

A total of 746 ECGs were collected: 466 from military men (62.4%) and 280 from military women (37.5%). Overall, the mean age was 29 ± 10.3 years (31 ± 10.7 years for men and 25 ± 8.5 years for women). All subjects were Caucasian, practiced sports more than three hours per week, and were not cigarette smokers. None of the participants displayed hypertension, dyslipidemia, diabetes, or a BMI >30 . The ECG results for the study population are summarized in Table 1. The prevalence of ERP was 13.8% (103/746); 16% (46/280) in women and 12% (57/466) in men, and no difference was noted for gender ($P > 0.05$). The prevalence of ERP according to age range is reported in Table 2 and Figure 2. The "inferior" location was the most common and was found in 71% of cases (73/103; 68% of men and 73% of women; Table 3). The "slurring" appearance represented 67% of cases (77% of men and 54% of women), and ST-segment elevation was found in 37% of cases (>2 mm in one case; Table 3). ERP+ men had a significantly lower heart rate, a shorter QT interval and a higher Sokolow index than ERP- men. In women, only the Sokolow index was statistically higher in the ERP+ group.

DISCUSSION

In this population of asymptomatic patients free of CVRF, a prevalence of ERP of 13.8% was found, whereas it is estimated at between 3.3% to 13.1% in the general population.² Indeed, in 2008, Haissaguere et al.³ found a prevalence of 5% in a control population of 412 patients with a mean age of 36.5 ± 12 years. In 2009, Tikkanen et al.⁵ found a prevalence of ERP of 5.8% in a cohort of 10,864 patients (7.1% among men and 4.6% among women). The mean age of this cohort

Table 1. ECG Parameters

	ECG (n) M/W	FC (bpm) M/W	P-Value	QT-Bazette Interval (ms) M/W	P-Value	Sokolow Index (cm) M/W	P-Value
Overall	466/280	70.8 ± 13.9; 75.9 ± 13.1	<0.001	398.7 ± 32.2; 414.5 ± 27.3	<0.001	3.078 ± 1.2; 2.3 ± 0.67	<0.001
<20 years	105/96	75.6 ± 15.4; 79.3 ± 13.6	0.08	401 ± 30; 413 ± 27.5	0.003	3.9 ± 1.1; 2.3 ± 0.67	<0.001
21–30 years	128/123	70.5 ± 13.5; 75.5 ± 13	0.003	395 ± 33; 412 ± 27.1	<0.001	3.2 ± 1.6; 2.36 ± 0.6	<0.001
31–40 years	112/34	67.8 ± 13; 70.2 ± 10	0.3	397.2 ± 29; 417.7 ± 28.3	<0.001	2.7 ± 0.6; 2.17 ± 0.5	0.04
41–50 years	121/27	69.6 ± 12.7; 72.9 ± 12	0.2	402 ± 34; 426.7 ± 24	0.003	2.6 ± 0.7; 1.85 ± 0.4	<0.001

bpm = beats per minute; ECG = electrocardiogram; FC = cardiac frequency; M = men; W = women.

Table 2. ERP Prevalence

	Overall M n/%	ERP+ M n/%	Overall W n/%	ERP+ W n/%	P-Value
Overall	466/62%	57/12%	280/38%	46/16%	0.1
<20 years	105/22.5%	21/20%	96/34%	15/15.6%	0.41
21–30 years	128/27.4%	14/11%	123/44%	22/18%	0.11
31–40 years	112/24%	9/8%	34/12%	7/20.6%	0.05
41–50 years	121/26%	13/10.7%	27/9.5%	2/7.4%	0.6

ERP = early repolarization pattern; M = men; W = women.

Table 3. ERP Locations and Observed Appearances

Lead Location/ Appearance	ERP+ M+W (n = 103) n/%	ERP+ M (n = 57) n/%	ERP+ W (n = 46) n/%	P-Value
Inferior lead	73/70%	39/68%	34/73%	0.5
Lateral lead	49/48%	31/54%	18/39%	0.1
Inferolateral lead	19/18%	13/22%	6/13%	0.2
Slurring	69/67%	44/77%	25/54%	0.34
Notching	43/42%	25/44%	18/39%	0.8
ST-segment elevation	38/37%	22/47%	16/35%	0.9

ERP = early repolarization pattern; M = men; W = women.

Figure 2. Early repolarization pattern prevalence is shown for men and women by age group.

was 44 ± 8.5 years; 34% of subjects were smokers and 8% had structural heart disease. In 2010, the MONICA/KORA⁶ study found a prevalence of 13.1% in a population of 6213 patients with a mean age of 52 ± 10 years, in which 52% of subjects were smokers, 41.2% were hypertensive and 4% were diabetic. In 2011, Noseworthy et al.⁷ found an ERP prevalence of 4.5% in two large cohorts

including 3995 American patients (Framingham Heart Study or FHS) and 5489 European patients (Health 2000 Study or H2K). The prevalence was 6.1% in the United States. FHS population and 3.3% in the European H2K population. The authors also found that ERP was associated with many clinical factors such as age, male gender, slow heart rate and high Sokolow index, and that the

prevalence of ERP decreased with age. CVRFs were not associated with ERP. In this study, the same clinical criteria were associated with ERP, and a decrease in the prevalence of ERP with age was also noted. Our young and sporty population of military officers is not strictly comparable with the general population described in the literature. Similarly, we cannot compare it with a series of top-level athletes; indeed, not all officers meet this definition. Juntilla et al.⁸ estimated the prevalence of ERP at 30% in a group of 503 male athletes. Wilhem et al.⁹ found a prevalence of 48% in a population of 54 professional soccer players. In 2012, Noseworthy et al.¹⁰ found a prevalence of 25% among 879 young athletes.

The fact that ERP are commonly found in our military population requires a pragmatic preventive medical approach, particularly in the absence of accurate electric criteria with which to identify patients at SD risk. Our practical approach in the military is set on two levels. At the individual level, a systematic ECG is carried out at incorporation to screen for ERP and is analyzed by a practitioner trained in ECG interpretation and familiar with ERP. If an ERP is detected in an asymptomatic military patient, primary prevention will focus on identifying an eventual history of SD or unexplained syncope in the family. If none is reported, no restriction of aptitude or physical activity will be placed. However, if a family history of SD and/or unexplained syncope is reported, the patient will undergo further investigations at a military hospital's cardiology department to screen for any structural pathology or at-risk channelopathy. Symptomatic patients, i.e., who present with one or more unexplained syncope, and whose etiological assessment remains negative, may face occupational limitations if his/her duties present specific risks (e.g., pilots, paratroopers, commandos, etc.). Secondary SD prevention includes the systematic implantation of a cardioverter-defibrillator,³ and the officer is then declared unfit to conduct any specific activity.

From a collective perspective, two key points should be emphasized: military authorities must have information regarding the risk of SD among young people, and medical teams must be trained in the management of cardiac arrest in non-hospital settings.¹¹ All medical and paramedical military staff must be trained in the use of manual or automated external defibrillators. A medical team

should be present when at-risk activities are undertaken, and an automated external defibrillator should be made available in isolated units. Medical staff training is critical to optimize the chain of survival.¹²

Understanding the association between ERP and SD due to VF has improved our medical knowledge. Thus, faced with a high prevalence of ERP in our population, we have integrated SD risk assessment into military officers' periodic medical examinations. Symptomatic patients (with unexplained syncope) receive special care with a systematic assessment by military cardiologists.

Acknowledgments: *None declared.*

REFERENCES

1. Massourel PL, Sacher F, Rigollaud JM, et al. Sudden cardiac death in young adult associated with early repolarization: which consequences in military medicine? *Medecine et Armées* 2010;38:257-261.
2. Benito B, Guasch E, Rivard L, et al. Clinical and mechanistic issue in early repolarization. *J Am Coll Cardiol* 2010;56:1177-1186.
3. Haïssaguerre M, Derval N, Sacher F, et al. Sudden cardiac arrest associated with early repolarization. *N Engl J Med* 2008;358:2016-2023.
4. Nam GB, Kim YH, Anzelevitch C. Augmentation of J waves and electrical storms in patients with early repolarization. *N Engl J Med* 2008;358:2078-2079.
5. Tikkanen JT, Anttonen O, Junttila MJ, et al. Long-term outcome associated with early repolarization on electrocardiography. *N Engl J Med* 2009;361:2529-2537.
6. Sinner MF, Reinhard W, Müller M, et al. Association of early repolarization pattern on ECG with risk of cardiac and all cause mortality: A population-based prospective cohort study (MONICA/KORA). *PLoS Med* 7(7):e1000314. doi:10.1371/journal.pmed.1000314.
7. Noseworthy PA, Tikkanen JT, Porthan K, et al. The early repolarization pattern in the general population. *J Am Coll Cardiol* 2011;57:2284-2289.
8. Junttila MJ, Sager SJ, Freiser M, et al. Inferolateral early repolarization in athletes. *J Interv Card Electrophysiol* 2011;31:33-38.
9. Wilhem M, Brem MH, Rost C, et al. Early repolarization, left ventricular diastolic function, and left atrial size in professional soccer players. *Am J Cardiol* 2010;106:569-574.
10. Wilhelm M, Brem MH, Rost C, et al. Early repolarization pattern in competitive athletes; clinical correlates and the effects of exercise training. *Circ Arrhythm Electrophysiol* 2011;4:432-440.
11. Rea TD, Page RL. Community approaches to improve resuscitation after out-of-hospital sudden cardiac arrest. *Circulation* 2010;121:1134-1140.
12. Fishman GI, Chugh SS, Dimarco JP, et al. Sudden cardiac death prediction and prevention: Report from a national heart, lung, and blood institute and heart rhythm society workshop. *Circulation* 2010;122:2335-2348.