SÃO PAULO MEDICAL JOURNAL

SPECIAL ARTICLE

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Signal-averaged electrocardiogram in chronic Chagas' heart disease

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The aim of the study was to register the prevalence of late potentials (LP) in patients with chronic Chagas' heart disease (CCD) and the relationship with sustained ventricular tachycardia (SVT). 192 patients (96 males), mean age 42.9 years, with CCD were studied through a Signal Averaged ECG using time domain analysis. According to presence or absence of bundle branch block (BBB) and SVT, four groups of patients were created: Group I (n = 72): without SVT (VT-) and without BBB (BBB-): Group II (n = 27): with SVT (VT+) and BBB-; Group III (n = 63): VT- and with BBB (BBB+); and Group IV (N = 30): VT+ and BBB+. The LP was admitted, with 40 Hz filter, in the groups without BBB using standard criteria of the method. In the group with BBB, the root-mean-square amplitude of the last 40 ms (RMS) < = 14μV was considered as an indicator of LP.

Results: In groups I and II, LP was present in 21 (78%) of the patients with SVT and in 22 (31%) of the patients without SVT ($p < 0.001$), with Sensitivity (S) 78%; Specificity (SP) 70% and Accuracy (Ac) 72%. LP was present in 30 (48%) of the patients without and 20 (67%) of the patients with SVT, in groups III and IV. $p = 0.066$, with S = 66%; SP = 52%; and Ac = 57%. In the follow-up, there were 4 deaths unrelated to arrhythmic events, all of them did not have LP. Eight (29,6%) of the patients from group II and 4 (13%) from group IV presented recurrence of SVT and 91,6% of these patients had LP. Conclusions: LP occurred in 77.7% of the patients with SVT and without BBB. In the groups with BBB, there was association of LP with SVT in 66,6% of the cases. The recurrence of SVT was present in 21% of the cases from which 91,6% had LP.

UNITERMS: Signal-averaged electrocardiogram. Ventricular tachycardia. Chagas' disease.

The signal-averaged electrocardiogram constitutes a noninvasive method whose purpose is to detect low voltage and high frequency potentials that occur at the end of a QRS complex and/or in the ST segment. These are called late potentials and they have been presumed as noninvasive markers of the arrythmogenic setting (1,3,5,6,10).

In chronic chagasic cardiopathy, the congestive cardiac failure is the final stages of its clinical progression. The occurrence of ventricular arrhythmias of the sustained ventricular tachycardia type and ventricular fibrillation or thromboembolic phenomena may interrupt this progression leading the patient to death (13,16).

The tachycardiac syndromes may occur as a consequence of changes in the formation (automatism) and/or in the conducting of electrical stimuli (reentry) (18,23).

The mechanism of reentry, habitually found in ventricles, depends, from the electrical point of view, on the slow conduction component, unidirectional block and

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on the recovery of the excitability distal to the block zone, thus favoring the genesis of ventricular ectopic rhythms (24,26).

The prevalence of sustained ventricular tachycardia or ventricular fibrillation in the chronic chagasic cardiopathy is unknown: as it is episodic, the recording of these findings during noninvasive examinations is rare (7,9,17).

The relationship between late potentials and chronic chagasic cardiopathy has not been previously investigated.

This study aimed at recording the prevalence of late potentials, by means of signal-averaged electrocardiogram in patients with chronic chagasic cardiopathy and their relationship to sustained ventricular tachycardia.

PATIENTS AND METHODS

One hundred and ninety two subjects with positive serological tests for chagasic cardiopathy were studied. Ninety six subjects were male patients, age range from 17 to 75 with an age average of 42,93 years.

The patients were subjected to the following exams: electrocardiogram, stress testing, long term electrocardiogram and signal-averaged electrocardiogram.

The follow-up period ranged from 9 to 57 months, with an average of 39,83 months.

The recurrence rate of sustained ventricular tachycardia was recorded and the causes of the death were rigorously investigated.

According to the electrographic findings showing the presence or absence of bundle branch block (BBB+ and BBB-) and the presence of sustained ventricular tachycardia (VT+ and VT-), all patients were divided into four groups:

Group I (VT-, BBB-) was made up of 72 patients, 41 (75%) were female. Age ranged from 17 to 75 (with an age average of 41,06 years).

Group II (VT+, BBB-): was made up of 27 patients, 13 (48%) were female. Age ranged from 28 to 64 (with an age average of 46,74 years).

Group III (VT-, BBB+): was made up of 63 patients, 31 (49%) were female. Ages ranged from 21 to 63 (with an age average of 40,84 years).

Group IV (VT+, BBB+): was made up of 30 patients, 11 (37%) were female. Ages ranged from 23 to 70 (with an age average of 48,36 years).

All four groups were subdivided into late potential negative and late potential positive when the presence or the absence of late potentials was respectively considered.

The statistical analysis was carried out through proportion tests, Fisher's exact test and chi-square test, always perceptive of the conditions of applicability.

The probability of occurrence of an error of the first kind (Type I Berquo), the only relevant error to the present study was fixed at 5% for all the tests.

All the calculations were made using the statistical software "Statgraphics" (Statistical Graphics System).

The statistical analysis also included the calculations of the operational variables, sensibility, specificity and accuracy, according to the elaborate formulas.

The System Art (Arrhythmia Research Technology Inc.), with a unit of 1200 EPX, a computerized analysis system, Standard 10 MHz, PC-AT with 40 MB, hard disk and EGA graphics and a Hewlett-Packard Laser Jet printer with memory expansion were used for the recording of the signal-averaged electrocardiogram in the 192 patients sample. It also contained the operation program of filters by computers including patients data management.

From 200 to 300 beats were selected by eliminating the ventricular ectopic beats through the algorithm acquisition module. The multiple cycles were superposed and the wave shapes were added and averaged. The signals were amplified and the spurious noises were ignored.

After the averaging, the signals went through a bi-directional filter of a large band (0,05 to 250 Hz) to reduce the signals of high voltage and low frequency.

The electrocardiographic signals were captured by bipolar derivations x, y and z which are represented by a vector whose magnitude is computer-calculated by making use of the root-mean-square method. This vector is known as QRS filters.

Subsequently, three variables were evaluated in the filtered QRS complex (8):

a) the duration of QRS (DQRS);

b) the root-mean-square voltage of the last 40ms (VM 40); and

c) the duration of the signal below 40μV (SBA).

In this research, the presence of late potentials was admitted in the group of patients without bundled branch block when at least two of the following criteria were present: DQRS >= 110ms; SBA >= 35mm and VM 40 <= 20μV (Fig. 1 and 2).

In this study, the criterion VM 40 <= 14μV was used to define the presence of late potentials in the patients with bundle branch block. This value was obtained from the analysis of data concentration, related to different levels of cut point values (from 12 to 18μV) with calculation of sensibility and specificity for all levels (Figs. 3 and 4).

The records were obtained during the clinical follow-up carried out at InCor. The cut of frequency (CF) - lower value - used was 40 Hz. The final noise value was accepted when <= 0,3μV with a gain of 2.000/4.000.

RESULTS AND DISCUSSION

The analysis of the findings of the signal-averaged electrocardiogram and its relationship with sustained ventricular tachycardia is:

Group I: Patients without bundle branch block and without sustained ventricular tachycardia. This group corresponded to 72 (37,5%) patients of the sample. Fifty (69,4%) patients presented no late potentials and 22 (30,6%) had late potentials. As it was observed, the prevalence of late potentials without sustained ventricular tachycardia, in this series of patients with chronic chagasic cardiopathy, is higher than the rate of 15% of patients with coronary artery disease. It is also higher than the rate of 14% of patients with dilated cardiopathy of other origins, both without sustained ventricular tachycardia (20).

The electrophysiologic changes found in the chronic chagasic cardiopathy due to the functional disorganization, may contribute to the emergence of late potentials, but without the background to sustain a reentry.

Group II: Patients without bundle branch block and with sustained ventricular tachycardia. This group corresponded to 14% of the sample. Late potentials were found in 21 (77,7%) of patients, while it was absent in 6 (22,3%). The prevalence of late potentials in patients with sustained ventricular tachycardia in chronic chagasic cardiopathy in this study is similar to the findings described by Poll and cols. (20) in patients with dilated cardiopathy of other etiologies. It was also found to be within the average rate observed in patients with coronary artery disease, that is, 70% to 93% (19).

There were false-negative results - absence of late potentials and sustained ventricular tachycardia. This observation may be related to:

a) presence of a small extension of the arrhythmogenic setting and/or its intermittent manifestation; b) arrhythmogenic mechanism of an abnormal automatism kind (21).

The influence of the Autonomic Nervous System imbalance may be associated to these two possibilities which may be verified in such condition (11).

The value of late potentials as a marker of sustained ventricular tachycardia in patients with chronic chagasic cardiopathy in the groups I and II showed a sensibility

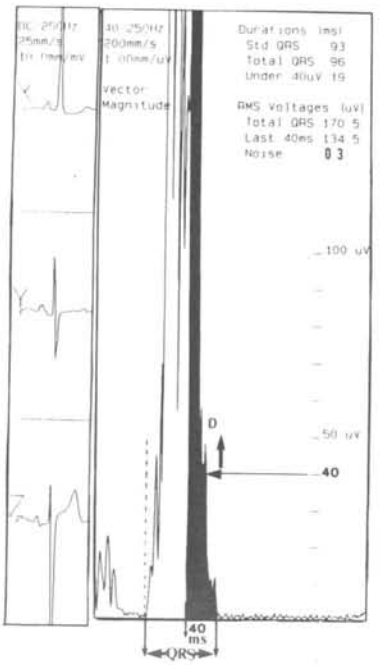

Figure 1. Viewing of the signal-averaged electrocardiogram in patients of group I without late potentials. The frequency cut point employed was 40 to 250 Hz. Represented one shows: the duration of the filtered QRS complex, the duration of the signal below 40μV (D) and the root-mean-square voltage of the final 40 ms of the QRS complex (bold type)

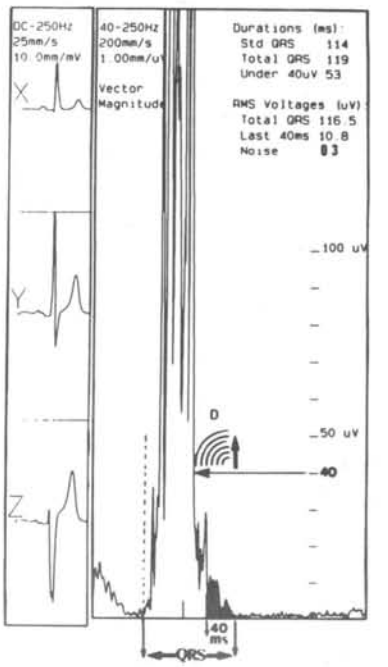

Figure 2. Viewing of the signal-averaged electrocardiogram in patients of group II with late potentials. Note the illustrations of the same parameters assessed in figure I. Observe the length and the small voltage (bold type) of the potential at the end of the filtered QRS complex.

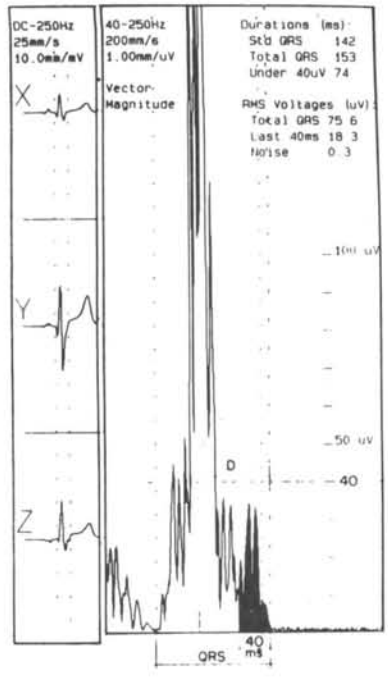

Figure 3. An example of signal-averaged electrocardiogram in patients of group III without late potentials in the presence of bundle branch block on the right-side branch. Note the value of the root-mean-square voltage of the last 40 ms (18,3μV).

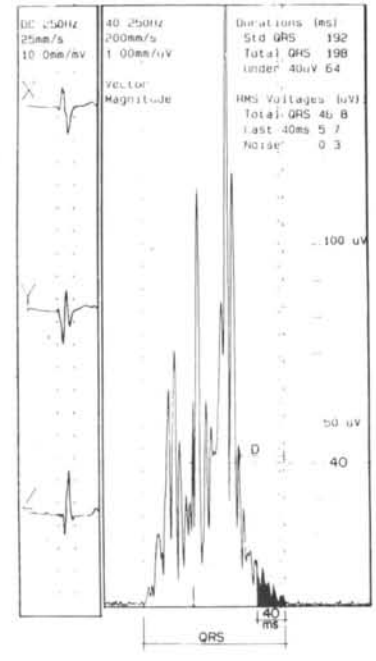

Figure 4. Viewing of the signal-averaged electrocardiogram in patients of group IV with late potential in the presence of bundle branch block on the right-side branch. The value of the parameter root-mean-square of the last 40 ms corresponds to 5,7μV which confirms the presence of a late potential.

degree of 78%, a specificity degree of 70% and an accuracy rate of 77%. The values reached in the study of patients with chronic chagasic cardiopathy were similar to those values resulting from the study described in the literature in patients with coronary artery diseases (11,19,21) and dilated cardiopathies, where Pols and cols. (20), achieved values for sensibility and specificity of 83% and 86% respectively.

The relationship between patients without bundle branch block with and without sustained ventricular tachycardia and the presence or absence of late potentials was statistically significant ($p < 0,001$).

Group III: Patients with bundle branch block and without sustained ventricular tachycardia corresponded to 32,8% of the sample, 33 (52,4%) patients did not have late potentials in the signal-averaged electrocardiogram while its presence was reported in 30 patients (47,6%).

This finding concerning the present of late potentials in a high number of patients without sustained ventricular tachycardia may be attributed to the following facts:

a) Out of the 30 patients with late potentials, 96,7% had ventricular arrhythmias with a predominance of non-sustained ventricular tachycardia. They are prone to have the anatomic settings for the occurrence of sustained ventricular tachycardia, but they may not have had conditions to develop it.

b) In the case of dilated cardiopathies of other etiologies, as well as the chagasic one, the presence of bundle branch block generates an asynchronous ventricular activation. This generates a signal that may be recorded as a late potential in the absence of actual background to the reentrant tachyarrhytmia (25). As previously discussed, there are sensible electrophysiologic and functional differences between the chronic chagasic cardiopathy and cardiopathies of other origins. Due to the magnitude of these changes and specially due to the disorganization that is consequent to the irregular distribution of the fibrosis, there may be an magnification of the signals fulfilling the criteria for a diagnosis of a late potential in the case of intraventricular blocks in chagasic cardiopathy (15).

Group IV: Patients with bundle branch block and sustained ventricular tachycardia. This group comprises 30 patients who represent 15,6% of the sample. Twenty (66,6%) had late potentials and 10 (33,4%) did not have late potentials. The percentage of individuals with late potentials as well as chronic chagasic cardiopathy was close to the average found in patients with coronary artery disease without bundle branch block (4,19,22).

The false-negatives (33,4%) could possibly be accounted for:

a) the involved mechanism in the tachyarrhythmia event may be that of an abnormal automatism and not that of reentry. Although the latter may be present, but with an arrhythmogenic setting of low magnitude, preventing its manifestation in the signal-averaged electrocardiogram;

b) the imbalance of a central or of a reflex origin, amid the sympathetic and parasympathetic autonomic activities, becomes an important hypothesis as an attempt to explain the arrhythmogenic disorders in chronic chagasic cardiopathy.

The cardiac autonomic dysfunction in chagasic cardiopathy may play an important role in the changes of the electrophysiologic properties of the heart, which may or may not be associated with lesions in the myocardium or in the conduction system (12).

For these 2 groups of patients with chronic chagasic cardiopathy with bundle branch block, the late potentials as a marker of risks for sustained ventricular tachycardia showed the following values: sensibility 66%; specificity 52%; accuracy 57%. The relationship between the number of patients of these two groups who had or did not have sustained ventricular tachycardia and late potentials was not statistically significant with a p value of 0,0666. This is probably due to the results obtained in the group III (patients without sustained ventricular tachycardia, 33 without late potential and 30 with late potential), contrasting to group IV which showed an agreement of findings in 66,6% of the cases and disagreement in 33,4%.

The clinical follow-up of the 192 patients was carried out in a period of time which varied from 9 to 57 months with an average of 39,83 months. During that period, four deaths occurred. All belonged to group III (VT- BBB+) and according to the information from the medical reports and relatives, such deaths did not relate to arrhythmic events. They did not show late potentials.

Recurrence of sustained ventricular tachycardia was observed in 8 (29,6%) of the patients in group II and in 4 (13%) of the patients in group IV. There was, however, recurrence in 21% of the cases. It is important to stress that out of 12 patients belonging to group II and IV who had sustained ventricular tachycardia, even in the period they were on antiarrhythmic drugs, late potentials were recorded in 11 (91,6%) of them.

CONCLUSIONS

The analysis of the signal-averaged electrocardiogram carried out in patients with chronic chagasic cardiopathy showed that the occurrence of late potentials in patients with sustained ventricular tachycardia and without bundle branch block was 77%. In the groups with bundle branch block, there was an association of late potentials with sustained ventricular tachycardia in 66,6% of the cases and the recurrence of sustained ventricular tachycardia was present in 21% of the cases; out of which 91,6% had late potentials.

Resumo

O estudo objetivou: estudar a prevalência de potencial tardio, em portadores de cardiopatia chagásica crônica, e sua relação com taquicardia ventricular sustentada. Foram estudados pelo eletrocardiograma de alta resolução 192 pacientes com Cardiopatia Chagásica Crônica, sendo 96 (50%) do sexo masculino. A idade variou entre 17 e 75 anos (média de 42,93). De acordo com presença ou ausência de bloqueio de ramo e taquicardia ventricular sustentada foram constituídos 4 grupos. Admitiu-se a presença de potencial tardio, com filtro de 40 Hz, nos grupos sem bloqueio de ramo, quando a duração do QRS filtrado $\geq$ 110 ms, duração do sinal abaixo de 40 µV $\geq$ 35ms e voltagem da raiz quadrada dos últimos 40ms (VM 40) $\leq$ 20 µV. Nos grupos com Bloqueio de ramo considerou-se o VM40 $\leq$ 14 µV como indicativo de potencial tardio. Resultados: nos grupos sem bloqueio de ramo o potencial tardio esteve presente em 21(78%) dos pacientes com taquicardia ventricular sustentada e em 22(31%) dos sem taquicardia ventricular sustentada ($p<0,001$), com sensibilidade (S) 78%, especificidade (E) 70% e acurácia (Ac) 77%. O potencial tardio esteve presente em 30 (48%) dos pacientes sem taquicardia ventricular sustentada e em 20 (67%) com taquicardia ventricular sustentada nos grupos com bloqueio de ramo ($p=0,066$) com S, 66%, E, 52% e Ac, 57%. No seguimento, 12 (21%) pacientes apresentaram recorrência de taquicardia ventricular sustentada: 91,6% destes pacientes tinham potencial tardio. Ocorreram quatro óbitos sem relação com eventos arrítmicos, todos pertencentes ao grupo com bloqueio de ramo e sem taquicardia ventricular sustentada, e com potencial tardio ausente. Conclusões: Potencial tardio ocorreu em 77,7% dos pacientes com taquicardia ventricular sustentada e sem bloqueio de ramo. Na ausência de bloqueio de ramo o eletrocardiograma de alta resolução diferenciou pacientes com e sem taquicardia ventricular sustentada. Nos grupos sem bloqueio de ramo observou-se S=78% , E=70% e Ac= 72%. Nos grupos com bloqueio de ramo, em 66,6% dos casos, houve associação entre potencial tardio e taquicardia ventricular sustentada. A recorrência de taquicardia ventricular sustentada esteve presente em 21% dos casos e destes 91,6% tinham potencial tardio.

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