



## Original article

ACTA FAC. MED. NAISS. 2005; 22 (1): 9-13

Dragan Đorđević, Branko Lović, Marina Deljanin Ilić, Ivan Tasić, Stevan Ilić, Bojana Stamenković, Dejan Petrović

Institute for Prevention, Treatment and Rehabilitation of Rheumatic and Cardiovascular Disease, Niška Banja

## CLINICAL SIGNIFICANCE OF SIGNAL-AVERAGED ELECTROCARDIOGRAM IN PATIENTS WITH ARTERIAL HYPERTENSION AND LEFT VENTRICULAR HYPERTROPHY

## SUMMARY

It is still unknown which factors determine the presence of positive signal-averaged electrocardiograms in hypertension and their prognostic power for adverse cardiovascular events.

The aim of the study was to examine the frequency of late potentials and spectral turbulence analysis as well as the correlation between noninvasive parameters and five-year prognosis of late potentials and spectral turbulence analysis in patients with arterial hypertension and left ventricular hypertrophy.

The study included 90 patients with hypertensive left ventricular hypertrophy and 35 healthy subjects. Patients were on regular medication therapy and were followed up for five years.

The positive late potentials were found in 17 (18.9%) patients and in 3 (8.6%) healthy subjects. The positive spectral turbulence analysis was found in 14 (15.5%) patients with left ventricular hypertrophy and in 2 (5.7%) healthy subjects. Independent predictor for positive late potentials was body surface area ( $p < 0.05$ ) and for positive spectral turbulence analysis was left ventricular mass index ( $p < 0.01$ ). The fifteen (16.7%) patients had cardiovascular and cerebrovascular adverse events. There was no correlation between positive late potentials and positive spectral turbulence analysis and bad outcome during the five-year follow-up of hypertensive patients.

**Key words:** arterial hypertension, left ventricular hypertrophy, late potentials, spectral turbulence analysis

## INTRODUCTION

The signal-averaged electrocardiogram (late potentials and spectral turbulence analysis) has the greatest clinical significance in patients with myocardial infarction predicting malignant ventricular arrhythmias and sudden death. Left ventricular hypertrophy in patients with arterial hypertension is independent predictor of sudden death, especially if patient has complex ventricular tachyarrhythmias.

Clinical significance of late potentials and spectral turbulence analyses is often discordant between different studies (1, 2). Late potentials can be found in healthy subjects in minor percentage (3). It is still unknown which factors determine the presence of ventricular late potentials in hypertension.

According to this, it is important to re-evaluate clinical significance of signal-averaged electrocardiogram in hypertensive patients with left ventricular hypertrophy.

## AIMS

The aim of the study was to examine the frequency of late potentials and spectral turbulence analysis as well as the correlation between noninvasive parameters and five-year prognosis of late potentials and spectral turbulence analysis in patients with arterial hypertension and left ventricular hypertrophy.

## MATERIAL AND METHODS

The study included 90 patients (56 male and 34 female), with average age  $55.2 \pm 8.3$  years, with essential arterial hypertension and left ventricular hypertrophy. The average left ventricular mass index was  $171.9 \pm 32.4$  g/m<sup>2</sup>, and left ventricular mass was  $337.9 \pm 74.0$  g. Mean duration of hypertension was  $12.3 \pm 7.9$  years. The control group included 35 healthy people (20 male and 15 female), with mean age  $54.5 \pm 7.1$  years. There were no differences between groups regarding age and gender.

All patients were examined by means of echocardiography (two independent examiners - Acuson-Sequoia), 24-h Holter monitoring (Del Mar Avionics), 24-h ambulatory blood pressure monitoring, heart rate variability, ventricular late potentials, spectral turbulence analysis and QTc interval dispersion. Parameters were measured at the beginning of the study. The patients were followed up for five years. All patients were on regular medicament therapy during the follow-up period.

The late potentials were obtained by Del Mar Avionics holter monitoring system using 25-250 Hz and 40-250 Hz filters with the noise level lower than 1  $\mu$ V. Parameters were positive if filtered QRS complex was  $\geq 114$  ms, root mean square amplitude of the last 40 ms (RMS40) was  $\geq 20$   $\mu$ V, and high frequency low amplitude signals less than 40  $\mu$ V (LAS40) was  $\geq 38$  ms. The late potentials were positive if two of the three parameters were positive as well (figure 1).

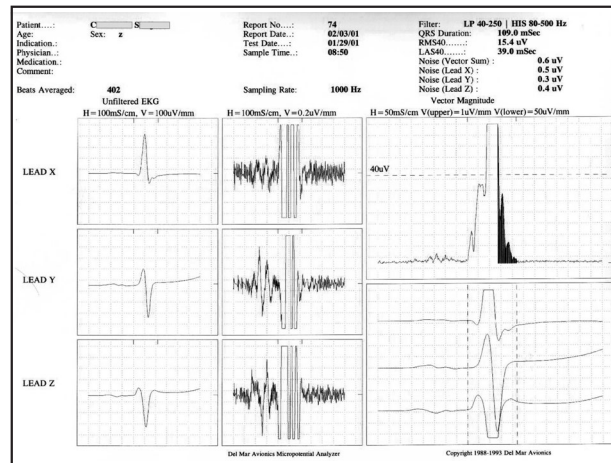


Figure 1. Positive late potentials

Positive parameters of spectral turbulence analysis were low slice correlations ratio  $> 73.5$ , Inter-slice correlation mean  $< 92.3$ , inter-slice correlation SD  $> 104.8$  and spectral entropy  $> 14.4$ . The finding of spectral turbulence analysis was positive if three of the four parameters were positive as well.

## RESULTS

The positive late potentials were found in 17 (18.9%) patients and in 3 (8.6%) healthy subjects. Statistical significance was not high. There was not any statistical difference between the examined parameters of late potentials in hypertensive group and healthy subjects (table 1).

The positive finding of spectral turbulence analysis was found in 14 (15.5%) patients with left ventricular hypertrophy and in 2 (5.7%) healthy subjects. There was no statistical difference between the examined parameters of spectral turbulence analysis in hypertensive group and healthy subjects (table 2).

Table 1. Parameters of late potentials in examined groups

Parameters (Filter 40-250 Hz)	Left ventricular hypertrophy	Healthy subjects	P
Filtered QRS complex (ms)	$94.2 \pm 12.0$	$90.5 \pm 11.6$	n. s.
RMS40 ( $\mu$ V)	$34.2 \pm 19.4$	$30.4 \pm 19.1$	n. s.
LAS40 (ms)	$30.9 \pm 8.3$	$29.0 \pm 13.8$	n. s.
Positive late potentials (n/%)	17 (18.9)	3 (8.6%)	n. s.

Table 2. Parameters of spectral turbulence analysis in examined groups.

Parameters	Left ventricular hypertrophy	Healthy subjects	P
Low slice correlation ratio	47.8 ± 16.9	46.2 ± 18.9	n. s.
Inter-slice correlation mean	91.8 ± 5.1	91.8 ± 6.2	n. s.
Inter-slice correlation SD	86.9 ± 54.1	70.9 ± 51.8	n. s.
Spectral entropy	18.6 ± 20.1	18.8 ± 22.6	n. s.
Positive spectral turbulence analysis (n/%)	14 (15.5%)	2 (5.7%)	n. s.

The positive finding of late potentials was correlated with body surface area ( $r = 0.275$ ;  $p < 0.01$ ), ejection fraction ( $r = -0.211$ ;  $p < 0.05$ ), morning systolic ( $r = 0.242$ ;  $p < 0.05$ ) and morning diastolic ( $r = 0.247$ ;  $p < 0.05$ ) blood pressure from 24-hours ambulatory blood pressure monitoring. Using multiple regression stepwise analysis, the independent predictor for positive finding of late potentials was body surface area ( $b = 0.248$ ;  $p < 0.05$ ).

The positive finding of spectral turbulence analysis was correlated with: left ventricular mass index ( $r = 0.341$ ;  $p < 0.01$ ), maximal systolic ( $r = 0.233$ ;  $p < 0.05$ ) and diastolic blood pressure ( $r = 0.223$ ;  $p < 0.05$ ) during the disease, 24-hour systolic blood pressure ( $r = 0.238$ ;  $p < 0.05$ ), 24-hour pulse pressure ( $r = 0.232$ ;  $p < 0.05$ ), and morning systolic ( $r = 0.221$ ;  $p < 0.05$ ) and morning diastolic ( $r = 0.213$ ;  $p < 0.05$ ) blood pressure from 24-hour ambulatory blood pressure monitoring. Using the multiple regression stepwise analysis, the independent predictor for positive finding of spectral turbulence analysis was left ventricular mass index ( $\beta = 0.341$ ;  $p < 0.001$ ).

Patients were followed up for five years and received regular antihypertensive therapy. Fifteen (16.7%) patients had cardiovascular and cerebrovascular adverse events (table 3). Non-sustained ventricular tachycardia was registered in 12 (13.3%) patients. There was no correlation between positive late potentials and positive spectral turbulence analysis and bad outcome during the five-year follow-up.

## DISCUSSION

Palatini et al. found late potentials in 25% out of 107 patients with arterial hypertension and in 6% out of 70 healthy subjects ( $p < 0.0001$ ). Frequently, hypertensive patients with late potentials had ventricular tachycardia ( $p < 0.05$ ). In multivariate analysis only the ratio E/A had predictive value for positive late potentials and ventricular tachycardia (1). Facchini et al. did not find differences in positive findings of late potentials between 49 patients with arterial hypertension and 89 healthy subjects (2). In our study, there were no significant differences in frequency of positive late potentials between hypertensive patients and healthy subjects. There was no correlation between ventricular arrhythmias and positive late potentials.

The influence of obesity on the appearance of late potentials was monitored in 105 people who were divided in 4 groups according to body mass index (4). The obese with body mass index greater than 30 kg/m<sup>2</sup> had positive late potentials in 55%. As for others, late potentials were present in 4.6%. Conclusion was that obesity was predictive factor for positive late potentials. In our study, we found significant correlation between positive late potentials and body surface area, but there was no correlation between late potentials and body mass index.

Table 3. Adverse cardiovascular and cerebrovascular events in the examined group

Adverse events	Number of patients	Description
Myocardial infarction	3	/
Cerebrovascular insult	5	2 patients died 1 patient - myocardial infarction
Angina pectoris	6	2 patients - coronary revascularization (one of them died during the operation)
Sudden death	1	/

Mercado et al. analyzed positive late potentials in elderly subjects (62-102 years old). The results were compared with the results of the group containing 179 patients with complex arrhythmias and the group of 25 healthy subjects under 50 years of age. In healthy elderly subjects, positive late potentials were found in 14%; in group with ventricular arrhythmias in 31% and in healthy young persons in 4%. Statistical difference was found only between young people and patients with ventricular arrhythmias (3). In our control group, late potentials were found in 8.6%.

It is still unknown which factors determine the presence of ventricular late potentials in hypertension. Wojszwillo et al. tried to solve this problem. They examined 109 patients with arterial hypertension. None of echocardiographic variables correlated with filtered QRS duration. However, a significant positive correlation between LAS40 and left ventricular mass and LAS40 and left ventricular end-diastolic volume, as well as a significant negative correlation between RMS40 and left ventricular mass were noted. The author concluded that left ventricular structure remodeling was the significant determinant of late potentials occurrence. In our study, the negative correlation was found between ejection fraction and positive late potentials (5).

Gottfridsson et al. found positive spectral turbulence analysis in 81% of patients with ischemic heart disease and monomorphic ventricular tachycardia and in 31% of patients without tachycardia ( $p < 0.0001$ ). In combination with late potentials, sensitivity was 90% for monomorphic ventricular tachycardia (6). There was not sufficient evidence for spectral turbulence analysis in patients with arterial hypertension and left ventricular hypertrophy. We found a good correlation between spectral turbulence analysis and left ventricular mass index but not between spectral turbulence analysis and ventricular tachyarrhythmias, which may be influenced by the absence of sustained ventricular tachycardia in our study.

## CONCLUSION

In patients with arterial hypertension and left ventricular hypertrophy, the positive correlation was found between positive late potentials and body surface area and between positive spectral turbulence analysis and left ventricular mass index. Signal-averaged electrocardiogram did not have the five-year predictive value for adverse cardiovascular events in patients with arterial hypertension and left ventricular hypertrophy.

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## **KLINIČKI ZNAČAJ UPROSEČENIH ELEKTROKARDIOGRAFSKIH SIGNALA KOD BOLESNIKA SA ARTERIJSKOM HIPERTENZIJOM I HIPERTROFIJOM LEVE KOMORE**

Dragan Đorđević, Branko Lović, Marina Deljanin Ilić, Ivan Tasić, Stevan Ilić, Bojana Stamenković, Dejan Petrović

*Institut za prevenciju, lečenje i rehabilitaciju reumatičkih i srčanih bolesti, Niška Banja*

### **SAŽETAK**

Još uvek je nepoznato koji faktori utiču na pojavu pozitivnog nalaza uprosečenih elektrokardiografskih signala u hipertenziji kao i njihova prognostička moć za nepovoljne kardiovaskularne događaje.

Cilj ove studije bio je da ispita učestalost kasnih komorskih potencijala i spektralne turbulentne analize, kao i povezanost između neinvazivnih parametara i petogodišnje prognoze kasnih komorskih potencijala i spektralne turbulentne analize kod pacijenata sa arterijskom hipertenzijom i hipertrofijom leve komore.

U studiji je ispitano 90 pacijenata sa hipertrofijom leve komore i 35 zdravih ispitanika. Pacijenti su bili na regularnoj medikamentnoj terapiji i praćeni su 5 godina.

Pozitivni kasni potencijali nađeni su kod 17 (18.9%) pacijenata i kod 3 (8.6%) zdrava ispitanika. Pozitivna spektralna turbulentna analiza nađena je kod 14 (15.5%) pacijenata i kod 2 (5.7%) zdrave osobe. Nezavisni prognostički marker za pozitivne kasne komorske potencijale bila je površina tela ( $p < 0.05$ ), a za pozitivnu spektralnu turbulentnu analizu indeks mase leve komore ( $p < 0.01$ ). Petnaest pacijenata (16.7%) je imalo nepovoljne kardiovaskularne i cerebrovaskularne događaje. Nije bilo povezanosti između pozitivnog nalaza kasnih komorskih potencijala i spektralne turbulentne analize sa lošim ishodom tokom 5 godina praćenja.

***Ključne reči:*** arterijska hipertenzija, hipertrofija leve komore, kasni komorski potencijali, spektralna turbulentna analiza