SHORT REPORT PEER REVIEWED | OPEN ACCESS

Pre-hospital use of high-frequency QRS analysis in healthy volunteers and patients with symptoms of coronary artery disease in acute care settings

Djordjevic Jelena, Velickovic Filip, Rajkovic Tatjana, Marinkovic Jelena, Mihajlovic Stevan, Milan Zoka

ABSTRACT

Aims: This study was performed to compare the difference in the incidence of abnormal high frequency QRS (HF-QRS) 12-lead finding and standard ECG ST-T segment changes, as an indicator of myocardial ischemia, between patients admitted to the accident and emergency (A&E) department for ischemic heart symptoms and a control group consisting of A&E departmental employees. Methods: The study group consisted of 24 patients admitted to the A&E department with some ischemic heart symptoms and the control group consisted of hospital employees who had no symptoms of coronary artery disease (CAD). Results: Control participants were an average of 10 years younger than the patients in the study group, and also had less history of diabetes mellitus and hypertension. The incidence rate of ST-T changes (Control vs patients 5.9% vs 29.2%, p=0.064) and HF-QRS changes (Control vs patients 23.5% vs 33.3%, p=0.497) were not different between the control and study group. However, HF-QRS changes were more frequent than ST-T changes (29.3% vs 19.5%, p < 0. 0001). There were no correlations between ST-T and HF-QRS changes in the two groups (Cramers V 0.089, p = 0.568). In univariate logistic regression analyses, the only predictor of positive HF-QRS was age (odds ratio [OR]: 1.112; 95% confidence interval [CI]: 1.019–1.213); each additional year of age was associated with an 11.2% increase in the risk of positive HF-QRS. However, none of the variables was a predictor of ST-T changes with significance level set at 0.05. Conclusion: In our pilot study, HF-QRS analysis detected more ECG changes indicating ischemia in acute settings than standard ECG ST segment changes. Larger studies are required to verify the role of HF-QRS technology in detecting early myocardial ischemia in pre-hospital setting.

Keywords: Coronary artery disease, Electrocardiography, High-frequency QRS, Pre-hospital, Volunteers

How to cite this article

Jelena D, Filip V, Tatjana R, Jelena M, Stevan M, Zoka M. Pre-hospital use of high-frequency QRS analysis in healthy volunteers and patients with symptoms of coronary artery disease in acute care settings. Edorium J Anesth 2017;3:1–6.

Article ID: 100012A05DJ2017

****

doi:10.5348/A05-2017-12-SR-1

Djordjevic Jelena[1], Velickovic Filip[1], Rajkovic Tatjana[1], Marinkovic Jelena[2], Mihajlovic Stevan[3], Milan Zoka[4]

Affiliations: [1]Doctor of Medicine, Emergency Medical Service Nis, Nis, Serbia; [2]Professors of Statistics, Belgrade School of Medicine, Belgrade, Serbia; [3]Consultant Anesthetist, Pancevo Hospital, Pancevo, Serbia; [4]Consultant Anesthetist, Honorary Professor of Anesthesia, King's College Hospital, London, UK.

Corresponding Author: Jelena Djordjevic, Nis, Republic of Serbia, 18000; Email: jelena711@yahoo.com

Received: 29 January 2017
Accepted: 19 April 2017
Published: 02 May 2017

INTRODUCTION

'Hyper-Q' technology or high-frequency QRS analysis (HF-QRS) is a relatively new non-invasive diagnostic method used for the detection of ischemic changes in electrocardiographic (ECG) traces, whether in the pre-hospital environment, during exercise testing, or during an attack of acute coronary syndrome [1, 2]. Compared to conventional detection of myocardial ischemia, which is based on changes in the repolarization phase of the cardiac cycle (i.e., ST-segment), HF-QRS technology is based on the detection of these changes during depolarization of the myocardium (i.e., QRS wave) [3].

Electrophysiologically, the standard classic interpretation of ECG analyses the deviation of the repolarization phase of the cycle in the lower frequency spectrum between 0.05 Hz and 100 Hz, using signals of lower amplitude. However, it has recently been theoretically postulated and experimentally confirmed that ischemic changes can be detected earlier, during the depolarization phase of the cardiac cycle, which is represented by the so-called hyper QRS waveform of smaller amplitude and much higher frequency (i.e., in the range of 150–250 Hz) [4, 5]. To detect these subtle changes, it is necessary to apply a specially designed computer algorithm consisting of several steps, including identification and capture of appropriate QRS waves, and their filtration and analysis with the aforementioned algorithm. The variables that are usually analyzed are the so-called 'Root Mean Squared' (RMS) voltage, and wave patterns known as a 'reduced amplitude zone' (RAZ). A decrease in the RMS and the presence of the RAZ are highly suggestive of acute myocardial ischemia [6].

First described in the 2000 [1], it has been extensively researched and clinically validated as an important diagnostic tool. So far, there is an evidence that:

- It has higher sensitivity in detecting acute coronary artery occlusion compared with conventional assessment of ST segment [6],
- It may improve noninvasive evaluation of coronary artery disease [7] ,
- It may improve the diagnosis of ischemia during exercise stress testing [8],
- In patients with chest pain, its valuable incremental prognostic role is particularly good in women [9].

However, little is known about the value of HF-QRS in pre-hospital setting. This study was performed to compare the results of HF-QRS and ST-segment changes derived from standard ECG test results between patients admitted to the accident and emergency (A&E) department for ischemic heart symptoms and a control group consisting of A&E departmental employees.

PATIENTS AND METHODS

This prospective observational study was performed in two groups: a study group and a control group. The study group consisted of 24 patients, 21 of whom were admitted to the A&E department with some ischemic heart symptoms including chest pain and/or shortness of breath and palpitations. Remaining three patients came to A&E department for 'non-cardiac symptoms' that may have been a part of the silent coronary syndrome. The control group consisted of hospital employees who had undergone a health check-up within one year before participation in the study and had no symptoms of CAD. All of the participants provided written informed consent, and the study was approved by the hospital's ethics committee. HF-QRS and ECG were performed in both patients and control subjects. HF-QRS data were recorded and analyzed by Cardiovit CS-200 Touch (Schiller, Switzerland) monitor. ST segment ECG changes were analyzed by authors 1 and 2, and the results were compared to the opinion of author 3. ST changes were: RS> 5 mm >rs, ST segment elevation or depression >1 mm and T wave changes. We also looked at a Q wave but there were no abnormal Q wave detected in any of our patients.

STATISTICAL ANALYSIS

All of the demographic data, symptoms, and ECG changes/HF-QRS changes were examined for statistical significance using the chi-square test, Fisher's exact test, or Student's t-test as appropriate. Univariate logistic regression analyses were performed to find predictors of HF-QRS and ST-segment changes. The correlation between HF-QRS and ST-segment changes (Cramers V) was also calculated. $P < 0.05$ was taken to indicate statistical significance.

RESULTS

As given in Table 1, control participants were an average of 10 years younger than the patients in the study group, and also had less history of diabetes mellitus and hypertension. However, both groups had similar family histories of cardiac disease, obesity, poor physical activity, stress, hyperlipidemia, and smoking. Patients in the control group had lower blood pressure and no cardiac or any other symptoms, as given in Table 2. The incidence rates of ST-T changes and HF-QRS changes were not different between the control and study groups (Table 3). However, HF-QRS changes were more frequent than ST-T changes (29.3% vs 19.5%, $p < 0.0001$). There were no correlations between ST-T and HF-QRS changes in the two groups (Cramers V 0.089, $p = 0.568$).

While abnormal ST-T changes were detected in only one patient in the control group (5.3%), abnormal HF-QRS was detected in four (23.5%) patients in this group. In univariate logistic regression analyses, the only predictor of positive HF-QRS was age (odds ratio [OR]: 1.112; 95% confidence interval [CI]: 1.019–1.213); each additional year of age was associated with an 11.2% increase in the risk of positive HF-QRS. For standardized age, the risk of HF-QRS increase was (OR: 4.436; 95% CI: 1.301–15.131), indicating a 4.43 higher risk of positive HF-QRS for one

Table 1: Demographic data and risk factors for coronary syndrome

Variable	Controls N=17	Patients N=24	p-value
Gender, n: male/ female	6/11	15/9	0.086
Age, mean (SD)	43.8 (10.85)	53.6 (14.84)	**0.026**
Family history, n: y/n	12/5	16/8	0.790
Hypertension, n: y/n	4/13	16/8	**0.006**
Diabetes, mellitus, n: y/n	0/17	5/19	**0.045**
Obesity n: y/s	3/14	5/19	0.800
Smoking n; y/n	7/10	11/13	0.767
Hyperlipidemia, n: y/n/u	6/10/1	10/12/2	0.848
Stress, n: y/n	16/1	18/6	0.109
Physical, activity, n: n/y	14/3	15/9	0.169

Table 2: Symptoms during admission to accident and emergency department

Variable	Controls N=17	Patients N=24	p-value
Systolic pressure, mean (SD)	115 (21.1)	148 (38.0)	**0.001**
Diastolic pressure, mean (SD)	74.1 (12.7)	84.7 (18.2)	**0.045**
Chest pain, n: n/y	0/17	15/9	**0.000**
Shortness, of, breath, n: n/y	0/17	8/16	**0.008**
Palpitations, n: n/y	0/17	7/17	**0.014**
Other symptoms n: n/y (%)	0/17	14/10	**0.000**
GIT symptoms, n: n/y	0/17	6/18	**0.026**
Neurological symptoms, n: n/y	0/17	3/21	0.130
Non-specific symptoms, n: n/y	0/17	5/19	**0.045**

Abbreviations: SD: Standard deviation, GIT: Gastrointestinal

standard deviation increase in age. However, none of the variables was a predictor of ST-segment changes with significance level set at 0.05.

The examples of normal and abnormal HF-QRS analysis are respectively shown in Figure 1 and Figure 2.

DISCUSSION

To our knowledge, this is the first study looking at the HF-QRS in pre-hospital A&E setting. Our results are consistent with those of similar previous studies, looking at the HF-QRS changes in different settings. A previous study [10] compared the HF-QRS and conventional ECG analysis for diagnosis of stress-induced ischemia during exercise test, which was performed in a population of women with risk factors for CAD. Both tests were compared to coronarography as the gold standard. The results indicated that HF-QRS analyses were more

Table 3: ST segment changes and high-frequency QRS changes (HF-QRS)

Variable	Controls N=17	Patients N=24	Total N=41	p-value
ST, n: y/n (%)	1/16 5.9/94.1	7/17 29.2/70.8	8/33 19.5/80.5	0.064
HF-QRS, n: y/n (%)	4/13 23.5/76.5	8/16 33.3/66.7	12/29 29.3/70.7	0.497

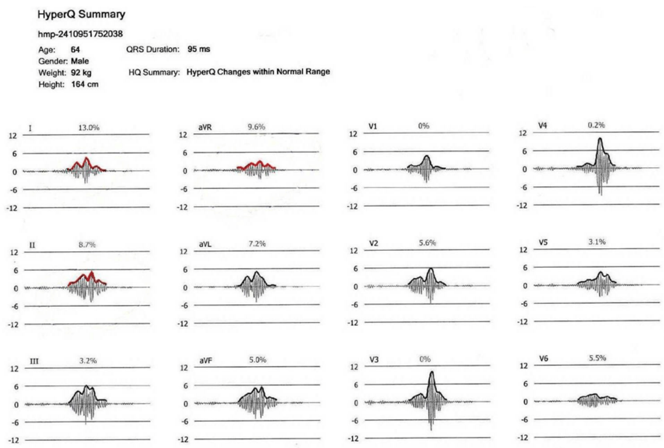


Figure 1: Study group patient admitted for chest pain. Several risk factors. Blood pressure was 190/105 mmHg. Unremarkable ECG ST-T changes. HF-QRS analysis is normal.

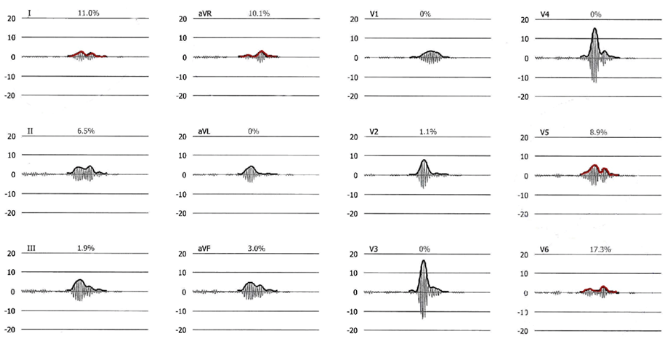


Figure 2: Control group patient under constant stress, with no symptoms. Unremarkable ECG ST-T changes and abnormal HF-QRS. Blood pressure was 90/60 mmHg. HF QRS software processes all 12 lead ECG data and mark abnormal data in red.

sensitive and specific for the detection of significant coronary artery stenosis compared to classic ECG ST-T changes analysis. Other studies performed in women showed similar results [11, 12]. In both of these studies, HF-QRS showed similar sensitivity and specificity compared to classic ECG analysis (78% and 86% vs. 77% and 83%, respectively). The results of these studies can easily be extrapolated to the general population because diagnosis is more difficult in women. Our results are also in accordance with those from a study by Conti et al. [9], who compared the diagnostic value of routine ST-T changes analysis of conventional ECG with HF-QRS analysis during exercise testing in a general population of patients with suspected CAD (i.e., chest pain and normal troponin tests, resting ECG, and echocardiography). In our study, each additional year of age was associated with an 11.2% increase in the risk of positive HF-QRS. Results of our pilot study suggest that HF-QRS analysis may find its place for early detection of potential ischemic changes in A&E settings.

Limitations of the study

The main limitation of this study was the small size of the study population. Therefore, the results of the logistic regression analyses should be interpreted with caution. In addition, there was no patient follow-up, and we did not compare our ST-changes and HF-QRS results with clinical outcomes and coronary angiography results.

CONCLUSION

In our pilot study, HF-QRS analysis detected more electrocardiogram (ECG) changes indicating ischemia in acute settings than standard ECG ST segment changes. Larger studies are required to verify the role of HF-QRS technology in detecting early myocardial ischemia in pre-hospital setting.

****

Author Contributions

Djordjevic Jelena – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published
Velickovic Filip – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published
Rajkovic Tatjana – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published
Marinkovic Jelena – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published
Mihajlovic Stevan – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published
Milan Zoka – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Guarantor

The corresponding author is the guarantor of submission.

Conflict of Interest

Authors declare no conflict of interest.

Copyright

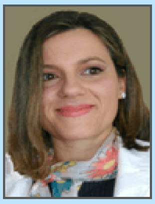
REFERENCES

1. www.bsp.co.il/hyperq-technology
2. Leinveber P, Halamek J, Jurak P. Ambulatory monitoring of myocardial ischemia in the 21st century-an opportunity for high frequency QRS analysis. J Electrocardiol 2016 Nov–Dec;49(6):902–906.
3. Amit G, Granot Y, Abboud S. Quantifying QRS changes during myocardial ischemia: Insights from high frequency electrocardiography. J Electrocardiol 2014 Jul–Aug;47(4):505–11.
4. Toledo E, Wagner GS. HyperQ—new horizons in ischemia detection. J Electrocardiol 2007;40(1)S37–S8.
5. Spackman TN, Abel MD, Schlegel TT. Twelve-lead high-frequency QRS electrocardiography during anesthesia in healthy subjects. Anesth Analg 2005 Apr;100(4):1043–7.
6. Pettersson J, Pahlm O, Carro E, et al. Changes in high-frequency QRS components are more sensitive than ST-segment deviation for detecting acute coronary artery occlusion. J Am Coll Cardiol 2000 Nov 15;36(6):1827–34.
7. Toledo E, Lipton JA, Warren SG, et al. Detection of stress-induced myocardial ischemia from the depolarization phase of the cardiac cycle: A preliminary study. J Electrocardiol 2009 May–Jun;42(3):240–7.

8. Lipton JA, Warren SG, Broce M, et al. High-frequency QRS electrocardiogram analysis during exercise stress testing for detecting ischemia. Int J Cardiol 2008 Feb 29;124(2):198–203.
9. Conti A, Bianchi S, Grifoni C, et al. High-frequency QRS analysis superior to conventional ST-segment analysis of women with chest pain. Am J Emerg Med 2016 Mar;34(3):437–42.
10. Rosenmann D, Mogilevski Y, Amit G, Davrath LR, Tzivoni D. High-frequency QRS analysis improves the specificity of exercise ECG testing in women referred for angiography. J Electrocardiol 2013 Jan–Feb;46(1):19–26.
11. Rosenman D, Mogilevski Y, Davrath LR, Abboud S, Tzivoni D. A novel technology enhances specificity of exercise testing in women referred for angiography. European Heart Journal 2010;31:980.
12. Rosenman D, Moglievski Y, Abboud S, Tzivoni D. Improving the specificity of exercise testing in women by high-frequency QRS analysis. JACC 2010;55:10A.

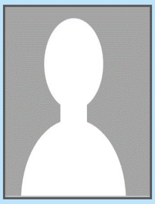
ABOUT THE AUTHORS

Article citation: Jelena D, Filip V, Tatjana R, Jelena M, Stevan M, Zoka M. Pre-hospital use of high-frequency QRS analysis in healthy volunteers and patients with symptoms of coronary artery disease in acute care settings. Edorium J Anesth 2017;3:1–6.

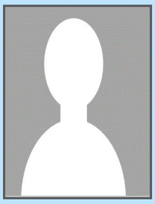


Djordjevic Jelena is currently working at Emergency Medical Service Nis, Nis, Serbia. Her area of interest include coronary artery disease.
Email: jelena711@yahoo.com

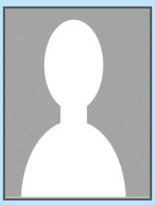
Velickovic Filip is currently working at Emergency Medical Service Nis, Nis, Serbia. His area of interest inculde kidney diseases and hypertension disorders. He intends to persue a fellowship in Nephrology.



Rajkovic Tatjana is currently working at Emergency Medical Service Nis, Nis, Serbia and she is member of European board Examination in Emergency Medicine. She earned postgraduate degree Emergency Medicine Specialist from Medical University Nis, Serbia and started PhD study at Medical University in Belgrade, Serbia. Her research interests include different emergency conditions. She has published more than 30 research papers in national and international academic journals.



Marinkovic Jelena Professors of Statistics, Belgrade School of Medicine, Belgrade, Serbia.



Mihajlovic Stevan Consultant Anesthetist, Pancevo Hospital, Pancevo, Serbia.

Milan Zoka is Consultant Anaesthetist at King's College Hospital, London, UK. She has published 120 research papers in national and international academic journals and authored two books. Her research interests include liver transplantation and hepato-biliary surgery, postoperative pain and data analysis.

Access full text article on
other devices

Access PDF of article on
other devices