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Prognostic value of the Selvester QRS score for re-hospitalization in patients with ischemic heart failure

İskemik kalp yetmezliği olan hastalarda tekrar hastaneye yatış için Selvester QRS skorunun prognostik değeri

Alper Karakuş [1], Berat Uğuz [2]

[1] Department of Cardiology, Besni State Hospital, Adıyaman, Turkey
[2] Department of Cardiology, Bursa City Hospital, Bursa, Turkey

ORCID ID of the author(s)

AK: 0000-0002-9632-395X
BU: 0000-0002-4834-5572

Abstract

Aim: The Selvester QRS score (SSc) on surface electrocardiogram (ECG) has prognostic value in various cardiac events related to myocardial scarring. Furthermore, the SSc system has been validated by post-mortem studies. In this cohort, we assessed the utility of the SSc system for prediction of re-hospitalization in patients with ischemic heart failure (HF).

Methods: In this retrospective cohort study, the data of fifty-four consecutive patients with ischemic HF were analyzed. ECGs were collected at first day of admission and SScs were calculated. The primary endpoint was re-hospitalization within the first 3 months.

Results: At baseline, the mean age was 62.1 years, LVEF was 29(6) %, NT-proBNP level was 2830 pg/mL. Twenty-one re-hospitalizations were observed due to HF. Patients who were re-hospitalized had significantly higher SScs than those who were not (5.6 vs.3.3 *P*=0.01). Cox regression analysis demonstrated that the SSc was an independent predictor of re-hospitalization rate (HR, 1.12; 95% CI, 0.95–1.34; *P*=0.04). Roc curve analysis showed that SSc was predictive for rehospitalization with a cut-off value 4.3, with a sensitivity of 65% and a specificity of 49% (AUC 0.618, *P*=0.02). Our analysis indicated a positive correlation between SSc with NT-proBNP and a negative correlation between SSc and LVEF (respectively r=0.33, *P*=0.03 and r =-0.67, *P*=0.04).

Conclusion: Our results suggest that baseline SSc can be used as a predictor of re-hospitalization due to ischemic HF.

Keywords: Heart failure, Re-hospitalization, Selvester QRS score

Öz

Amaç: 12 derivasyonlu elektrokardiyogramda Selvester QRS skorunun miyokardiyal skarla ilgili çeşitli kardiyak olaylardaki prognostik etkileri bilinmektedir. Ayrıca, Selvester QRS skor sisteminin otopsi ile ölçülen miyokardiyal skar boyutu ile de yüksek derecede korelasyona sahip gösterilmiştir. Bu çalışmada, Selvester QRS skorunun iskemik kalp yetmezliğine bağlı yeniden hastaneye yatışı öngörmedeki rolünü değerlendirmeyi amaçladık.

Yöntemler: İskemik kalp yetmezliği olan elli dört hastanın verileri geriye dönük olarak incelendi. Hastaneye başvuru sırasındaki EKG'ler temel alınarak Selvester QRS skorları hesaplandı. Birincil son nokta, ilk 3 ay içindeki yeniden hastaneye yatış kabul edildi.

Bulgular: Çalışma popülasyonunda, ortalama yaşın 62,1 yıl, sol ventrikül ejeksiyon fraksiyonun (LVEF) %29(6), plazma beyin natriüretik peptit seviyesin (NT-proBNP) 2830 pg / mL olduğu görüldü. Çalışma boyunca 21 hastaneye yeniden yatış gözlendi. Yeniden hastaneye yatırılan hasta grubunda Selvester skoru, diğer gruba göre anlamlı olarak daha yüksekti (5,6'ya karşı 3,3 *P*=0,01). Cox orantısal risk regresyon analizi, Selvester QRS skorunun yeniden hastaneye yatış için bağımsız bir belirleyici olduğunu ortaya koydu (HR, 1.12; %95 güven aralığı, 0,95-1,34; *P*=0,04). En iyi cut-off değeri %65 duyarlılık ve %49 özgüllük ile 4,3 puan olarak belirlendi (eğri altındaki alan, 0,618, *P*=0,02). Ayrıca Selvester QRS skoru ile NT-proBNP arasında anlamlı pozitif korelasyon (r=0,33, *P*=0,03) ve Selvester QRS skoru ile LVEF arasında negatif korelasyon saptandı (r=-0,67, *P*=0,04).

Sonuç: Bulgularımız, başvuru anındaki Selvester QRS skorunun iskemik kalp yetmezliğine bağlı yeniden hastaneye yatışın bir öngörücü olarak kullanılabileceğini düşündürmektedir.

Anahtar kelimeler: Kalp yetersizliği, Yeniden hastaneye yatış, Selvester QRS skoru

Corresponding author/Sorumlu yazar:
Alper Karakuş
Address/Adres: Besni Devlet Hastanesi Kardiyoloji Bölümü, 02300, Adıyaman, Türkiye
E-mail: alpkarakus06@gmail.com

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Introduction

Heart failure (HF) most often develops due to ischemic scar tissue caused by myocardial infarction [1]. Today, HF is considered a global health problem. It remains a prominent cause of recurrent hospitalizations despite optimal treatment [2].

Myocardial scar assessed on cardiovascular magnetic resonance (CMR) is associated with poor outcome in HF [3]. However, CMR is not in widespread clinical use. The electrocardiography (ECG) is an inexpensive, easily accessible, reproducible, and non-invasive diagnostic tool which provides risk stratification regarding myocardial scars [4]. The Selvester QRS score (SSc), first described in 1972, provides data on myocardial scar location and size using changes in cardiac electrical activity on surface ECG and its validation has been shown in autopsy series [5,6]. This primary version of the SSc could only be applied in the absence of confounders. So, the SSc QRS system criteria were presented with a new version in 2009 to expand their utility in patients with bundle branch blocks, fascicular blocks or ventricular hypertrophy. The simplified version of SSc consists of 37 criteria and 29 points [7].

Previous studies have documented the capability of SSc as prognostic markers for cardiac events in different clinical entities (including ST elevation myocardial infarction, aortic stenosis, nonischemic dilated cardiomyopathy), by reflecting the amount of myocardial fibrosis [7,9].

In this current study, we hypothesized that SSc, which reflects the amount of scar, has a prognostic significance in HF with ischemic origin and can be used for hospitalization. So, the current study was built to determine the utility of the SSc system for prediction of recurrent hospitalization due to ischemic HF (prior myocardial infarction (MI)).

Materials and methods

Study design and patients

This study was conducted at Besni State Hospital (Adıyaman, Turkey) and completed in collaboration with Bursa City Hospital (Bursa, Turkey). The study protocol was approved with registration number of 2020 – 7/8 by the Bursa City Hospital Ethics committee.

Assuming an alpha of 0.05, a power of 0.80, and with 30% estimated re-hospitalization rate in line with the previous reports, the estimated sample size was at least 46 patients in total.

The study inclusion criteria were as follows:

- Patients with HFrEF
- Prior MI (over > 3 months)

The study exclusion criteria were as below:

- Patients with newly arisen, de novo, non-ischemic HF or cardiomyopathy
- Patients with ICD or pacemaker
- Acute coronary syndrome within 3 months of the study
- Atrial fibrillation at admission
- Any more than mild valvulopathy
- Patients with preexcitation syndrome
- Patients who do not receive optimal treatment
- Patients with electrolyte imbalances

Consecutive fifty-seven patients with ischemic HF (with Reduced Ejection Fraction, HFrEF) who met the inclusion criteria were enrolled in this cross-sectional study. HFrEF was diagnosed and treated based on the criteria of ESC 2016 Guidelines for the diagnosis and treatment of acute and chronic HF [10].

Patient data including demographic, electrocardiographic and echocardiographic measurements, laboratory data and medical treatments were obtained. Follow-up information was collected for each patient regarding hospitalization, MI, and death at 3 months. For avoiding any selection bias against hospitalization, the patients with possible pathologies that could affect The SSc before or during follow-up were excluded and hospitalization indications for all patients were determined in terms of the need for intravenous treatment, in accordance with current guidelines. Patients were divided into two groups based on rehospitalization (due to HF) within 3 months.

Electrocardiographic analysis

The ECG measurements were made using a Cardiofax M ECG-1350K (Nihon Kohden, Tokyo, Japan, paper speed of 25 mm/sec, signal size of 1 mV/cm) at the time of admission. The electrocardiographic reader was blinded to study groups. The simplified version of SSc (37-criteria/29-point) was retrospectively calculated for each patient according to an algorithm, as previously reported [7].

Briefly; First, ECGs were classified according to primary ventricular conduction or hypertrophy type. Second, the SSc system was used for the primary conduction/hypertrophy type, which includes measurements of Q-, R-, and S-wave notches, amplitudes and its ratios and durations.

Statistical analysis

Normality was analyzed by The Kolmogorov-Smirnov test. According to the normality pattern, Student's T test and Mann-Whitney U test were used. Analysis results were presented as mean (standard deviation). For categorical variables, the Chi-square test was used, and the results were presented as percentages. To assess the association between SSc and HFrEF, two categories were defined on basis of re-hospitalization. The effects of different variables on re-hospitalization were determined with multivariate analysis. *P*-value<0.05 was considered statistically significant. SPSS 26.0 Statistical Package Software was used to perform all data analyses.

Results

Fifty-seven patients were evaluated for the study. Three patients were excluded from the cohort (one patient died, and 2 had MI during follow-up). The data of the remaining 54 patients were analyzed. The study group was divided into two based on rehospitalization at the end of the 3-month follow up. Of the 54 patients, twenty-one re-hospitalizations due to HF were observed. The median age of 54 patients was 62.1(12.7) years, Left Ventricular Ejection Fraction (LVEF) was 29(6) %, N Terminal prohormone brain natriuretic peptide (NT-proBNP) level was 2830 pg/mL.

Baseline clinical and demographic characteristics

Table 1 shows the detailed baseline characteristics (demographic/clinical) of study populations. On admission, there was no significant difference between the two groups regarding age, hypertension, diabetes mellitus, coronary artery disease, median Left Ventricular Ejection Fraction (LVEF), median estimated Glomerular Filtration Rate (GFR), and median NT-

proBNP. The comparison of the study patients regarding HF features is presented in Table 2.

Table 1: Baseline characteristics and laboratory findings of the study patients

Variables	Patients with re-hospitalization (Group 1, N=21, 38.8%)	Patients without re-hospitalization (Group 2, N=33, 61.1%)	*P*-value
Age (years)	61.5(17.4)	62.4(13.5)	0.69
Sex (n, %) females	10 (47.6%)	16 (48.4%)	0.77
Hypertension, (n, %)	7 (33.3%)	12 (36.3%)	0.81
DM, (n, %)	3 (14.2%)	4 (12.1%)	0.51
Creatinine (mg/dl)	1.26 (0.44)	1.31 (0.51)	0.33
HsCRP (nmol/L)	2.7 (0.8)	2.5 (0.5)	0.76
NT-proBNP (pg/mL),	2796 (1254)	3105 (1388)	0.21
TSH (µIU/mL)	2.34 (1.1)	2.19 (1.5)	0.34
Na (mmol/L)	137 (6.5)	138 (9.3)	0.22
K (mmol/L)	4.5 (1.2)	4.4 (0.9)	0.44
Leukocyte (10^9/L)	9.9 (5.2)	9.6 (3.4)	0.29
Hemoglobin (g/dl)	12.5 (3.4)	12.9 (3.1)	0.63
Platelet (10^9/L)	232 (69)	251 (79)	0.17

DM: Diabetes mellitus, HsCRP: High sensitive C reactive protein, NT-proBNP: N Terminal prohormone brain natriuretic peptide, TSH: Thyroid-stimulating hormone, Na: Sodium, K: Potassium

Table 2: Comparison of the study patients regarding heart failure features

Variables	Patients with re-hospitalization (Group 1, N=21, 38.8%)	Patients without re-hospitalization (Group 2, N=33, 61.1%)	*P*-value
Ejection fraction, (%)	28.2 (6.5)	29.4 (5.9)	0.61
Heart rate, median, beats/min	72 (23)	75 (31)	0.13
QRS duration, median, ms	111 (21)	114 (19)	0.17
NYHA heart failure			
▪ Class 3	42%	41%	0.73
▪ Class 4	58%	59%	0.88
Drug treatment (n)			
• ACEi/ARBs/ARNI	21	33	0.14
• Beta Blockers	21	33	0.14
• MRAs	21	33	0.14
• Ivabradine	6	9	0.09
• Diuretics	21	33	0.14

NYHA: New York Heart Association, ACEi: Angiotensin converting enzyme inhibitor, ARBs: Angiotensin receptor blockers, ARNI: Angiotensin receptor neprilysin inhibitor, MRA: Mineralocorticoid receptor antagonists

The Selvester QRS score and re-hospitalization

Patients who were re-hospitalized had significantly higher SSc values than those who were not (5.6 vs.3.3 P= 0.01). The models of regression were assessed for rehospitalization regarding gender, age, creatinine, NTproBNP, LVEF, and SSc. Cox regression analysis revealed that SSc was an independent determinant of re-hospitalization (HR, 1.12; 95% CI, 0.95–1.34; P=0.04). Roc curve analysis showed that SSc was predictive for rehospitalization with a cut-off value 4.3, with a sensitivity and a specificity of 65% and 49%, respectively (AUC 0.618, P=0.02).

Correlations were constructed for age, NTproBNP, LVEF and SSc. There was a significant positive correlation between SSc with NT-proBNP and a negative correlation between SSc and LVEF (r=0.33, P=0.03 and r =-0.67, P=0.04, respectively). No significant correlation was found in terms of other parameters (P>0.05).

Discussion

Our findings suggest that SSC can be an independent determinant of re-hospitalization in patients with ischemic HFrEF. The odds of rehospitalization increase with SSc values. Our findings suggest that the predictive cut-off value for rehospitalization was 4.3 points with 65% sensitivity and 49% specificity.

ECG findings such as pathological Q waves and QS complexes, widened QRS, left branch bundle block (LBBB), prolonged PR interval and increased heart rate are all associated with poor outcomes in HF [11]. Despite their prognostic value, their utility for clinical risk stratification is limited when used alone. Beyond traditional ECG diagnostic assessment, Selvester et al. developed a system using a series of abnormal findings on ECG, which considered each QRS-point as representing an infarct the equivalent of 3% of the LV. In this scoring system, higher scores correlate with larger scar sizes [12]. So, we believed that detection of myocardial scar by SSc, which is an inexpensive and easily available method, in HF patients may be more appropriate instead of the other cardiac imaging modalities.

In this cohort, 46.3% of the patients presented with ECG confounders. There were 12 patients with LBBB (22.2%), 2 with right branch bundle block (RBBB) (3.7%), 3 with left anterior fascicular block (LAFB) (5.5%), 3 with RBBB and LAFB (5.5%), 5 with left ventricular hypertrophy (9.2%). One of most important points of the present study is the timing of the ECG capture. ECGs were collected at first day of admission to avoid subtle ECG changes which may occur during treatment. The patients in our study had HF symptoms and were classified as NYHA functional class 3 or 4. Our results show that there was a higher SSc trend in re-hospitalized patients. Previous studies, which yielded comparable results to ours, evaluated the diagnostic performance of the QRS scores in various events among HF subjects. The mean QRS score in nonischemic dilated cardiomyopathy patients was reported as 4.2 points by Hiraiwa et al. [13]. Wieslander et al. [14] showed that SSc was a strong predictor of LV remodeling (echocardiographic) than clinical outcomes in HF patients. Additionally, Strauss et al. [15] demonstrated that subjects with no myocardial scar based on SSc have less ventricular arrhythmia events. We found a positive relationship between SSc and NTproBNP, which is an indicator of decompensation. It was not surprising that we found a negative correlation between SSc and LV EF. Although there was no difference regarding LVEF between the groups, there was a difference in QRS scores. It may be partially explained by the fact that a dissociation in conduction pathway can occur after MI, which may explain the relatively low sensitivity and specificity of SSc in our study. Nevertheless, our data suggest that SSc is a potential candidate for clinical risk stratification to predict myocardial scar and cardiac events in HFrEF.

Limitations

This study has some limitations worth noting, beginning with limited sample size, and its single center design. Also, a subgroup analysis for each ECG confounder could not be performed. There is a need for larger and multi-center studies investigating long term clinical outcomes. Our results are only applicable to patients with HFrEF due to ischemia. Beyond these limitations, we believe that higher value of SSc can be used for the risk stratification of patients with ischemic HFrEF. Therefore, we expect this study to be helpful for upcoming research.

Conclusions

Mortality, morbidity, quality of life and long-term survival in patients with HF are directly related to the grade of ventricular dysfunction. Our analysis showed that ECG quantification of myocardial scar with SSc can be used as a predictor of re-hospitalization due to ischemic HF. Patients with higher myocardial scar scores have an increased risk of decompensation and re-hospitalization.

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