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Original article

The Selvester QRS score as a predictor of cardiac events in nonischemic dilated cardiomyopathy

Hiroaki Hiraiwa (MD)[a], Takahiro Okumura (MD, PhD) [a,*], Akinori Sawamura (MD, PhD)[a], Yuki Sugiura (MD)[a], Toru Kondo (MD)[a], Naoki Watanabe (MD)[a], Soichiro Aoki (MD)[a], Takeo Ichii (MD)[a], Katsuhide Kitagawa (MD)[a], Naoaki Kano (MD)[a], Kenji Fukaya (MD, PhD)[a], Kenji Furusawa (MD)[a], Ryota Morimoto (MD, PhD)[a,b], Kyosuke Takeshita (MD, PhD)[a,c], Yasuko K. Bando (MD, PhD)[a], Toyoaki Murohara (MD, PhD, FJCC)[a]

[a] Department of Cardiology, Nagoya University Graduate School of Medicine, Nagoya, Japan
[b] Department of CKD Initiatives Internal Medicine, Nagoya University Graduate School of Medicine, Nagoya, Japan
[c] Department of Clinical Laboratory, Nagoya University Hospital, Nagoya, Japan

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ABSTRACT

Background: Myocardial fibrosis is associated with poor prognosis in nonischemic dilated cardiomyopathy (NIDCM) patients. The Selvester QRS score on 12-lead electrocardiogram is associated with both the amount of myocardial scar and poor prognosis in myocardial infarction patients. However, its use in NIDCM patients is limited. We investigated the prognostic value of the QRS score and its association with collagen volume fraction (CVF) in NIDCM patients.

Methods: We enrolled 91 consecutive NIDCM patients (66 men, 53 ± 13 years) without permanent pacemakers or cardiac resynchronization therapy devices. The Selvester QRS score was calculated by two expert cardiologists at NIDCM diagnosis. All patients were followed up over 4.5 ± 3.2 years. Cardiac events were defined as a composite of cardiac death, hospitalization for worsening heart failure, and lethal arrhythmia. We also evaluated CVF using endomyocardial biopsy samples.

Results: At baseline, the left ventricular ejection fraction was 32 ± 9%, plasma brain natriuretic peptide level was 80 [43–237] pg/mL, and mean Selvester QRS score was 4.1 points. Twenty cardiac events were observed (cardiac death, $n = 1$; hospitalization for worsening heart failure, $n = 16$; lethal arrhythmia, $n = 3$). Cox proportional hazard regression analysis revealed that the Selvester QRS score was an independent determinant of cardiac events (hazard ratio, 1.32; 95% confidence interval, 1.05–1.67; $p = 0.02$). The best cut-off value was determined as 3 points, with 85% sensitivity and 47% specificity (area under the curve, 0.688, $p = 0.011$). In Kaplan–Meier survival analysis, the QRS score ≥3 group had more cardiac events than the QRS score <3 group (log-rank, $p = 0.007$). Further, there was a significant positive correlation of Selvester QRS score with CVF ($r = 0.46$, $p < 0.001$).

Conclusions: The Selvester QRS score can predict future cardiac events in NIDCM, reflecting myocardial fibrosis assessed by CVF.

Introduction

Heart failure (HF) is a progressive systemic disease and a major public health problem with economic and social burden in developed countries. Despite modern progress in medical management, HF remains a common cause of recurrent hospitalization or death [1]. A number of prognostic predictors of HF have been reported, including plasma brain natriuretic peptide (BNP) level on blood test, cholesterol metabolism, circadian blood pressure profile, and peak oxygen consumption on cardiopulmonary exercise testing [2–7]. In particular, the progression of myocardial fibrosis assessed by late gadolinium enhancement on cardiovascular magnetic resonance (CMR) or endomyocardial biopsy (EMB) is associated with poor outcome in nonischemic dilated cardiomyopathy (NIDCM) [8]. However, development of a

* Corresponding author at: Department of Cardiology, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan.
E-mail address: takaoku@med.nagoya-u.ac.jp (T. Okumura).

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simple, low cost, and noninvasive method for risk stratification is urgently required to reduce healthcare costs and to reduce the burden of HF for patients and medical staff.

Twelve-lead electrocardiogram (ECG) is a standard cardiac examination, and is low cost, noninvasive, reproducible, rapid, and usable anywhere. Abnormal findings on ECG such as fragmented QRS or bundle branch block [9–11] and prolonged QRS duration were reported as prognostic predictors in HF patients [12,13]. In the 1980s, Selvester et al. developed a unique QRS scoring system composed of 32 points, in which each point was allocated 3% of the left ventricular (LV) mass [14]. In addition, the QRS score was reported to reflect and quantify myocardial scar volume despite the presence of abnormal ventricular conduction, and to have prognostic value in patients with ischemic cardiomyopathy [15–17]. However, the prognostic value of the QRS score in NIDCM patients remains unclear.

In the present study, we hypothesized that the Selvester QRS score predicts future cardiac events in NIDCM patients, reflecting the amount of myocardial fibrosis. The aim of this study was to investigate the prognostic value of the Selvester QRS score and the relationship between the QRS score and myocardial fibrosis in NIDCM.

Methods

Study population

We enrolled 91consecutive NIDCM patients between April 2006 and March 2015 in this single center prospective observational study. All patients were hospitalized in our institute for making a definite diagnosis of cardiomyopathies under each individual stable condition of HF. The patients underwent 12-lead ECG, laboratory measurements, echocardiography, coronary angiography, right heart catheterization, and EMB within one week to exclude secondary cardiomyopathies. NIDCM was defined as LV ejection fraction <50% on echocardiography and LV end-diastolic dimension >55 mm, in the absence of coronary artery diseases, primary valvular heart disease, or secondary cardiac muscle disease caused by any known systemic condition. We excluded patients with implantable pacemakers or cardiac resynchronization therapy devices. The study protocol was approved by the Ethical Review Board of our institute, and consent was obtained from all patients.

Selvester QRS score

Twelve-lead ECG was recorded at the time of scheduled admission by electrocardiograph (FCP-7541; Fukuda Denshi Co. Ltd, Tokyo, Japan). The 32-point Selvester QRS score was manually calculated by two expert cardiologists according to an algorithm, as previously reported [18]. If both scores were not matched, the QRS score was calculated by the third cardiologist in a blinded manner and finally determined. Initially, we categorized QRS complex morphology into six types: left bundle branch block (LBBB), right bundle branch block (RBBB), left anterior fascicular block (LAFB), LAFB with RBBB, LV hypertrophy, and no confounders. LV hypertrophy was defined as increased voltage according to Sokolow-Lyon or Cornell criteria and not meeting other classifications. Next, the amplitude, duration, amplitude ratio, and notch of the Q, R, and S waves were evaluated in each lead except for III or aVR. This scoring criterion was different for each QRS complex morphology, and the QRS score was individually calculated based on each criterion.

Hemodynamic assessment and histological analysis

Initially, all patients underwent routine diagnostic right heart catheterization to assess hemodynamic status. After collecting hemodynamic data, we performed EMB, as follows. Biopsy samples were obtained from the septum of the right ventricle with a 6-F transcatheter bioptome. The tissue was fixed immediately in 10% buffered formalin and embedded in paraffin, and then stained with the collagen-specific dye picrosirius red (Sigma–Aldrich, St Louis, MO, USA). Three or four samples were obtained and analyzed for each patient. The collagen volume fraction (CVF), the ratio of collagen-specific staining to the total area of the myocardium in each biopsy sample, was calculated as an index for interstitial collagen using automated image analysis software (BZ 9000; KEYENCE Co. Ltd., Osaka, Japan) by two observers in a blinded manner [19].

Patients classification and follow-up

Expert cardiologists followed up with optimal medical therapy according to the current guidelines for the treatment of HF [20,21]. Cardiac events were defined as a composite of cardiac death, unexpected hospitalization because of worsening HF, and lethal arrhythmia.

Statistical analysis

All statistical analyses were performed by using statistical software (SPSS 18.0; SPSS, Chicago, IL, USA). Continuous variables are expressed as means ± standard deviation or as median and interquartile range, as appropriate. Parametric variables were compared using the Student's *t*-test, and non-parametric variables were compared using the Mann–Whitney *U*-test. Categorical variables are expressed as numbers (%), and were compared using the Pearson chi-squared test or Fisher's exact test. Univariate and multivariate Cox proportional hazard analysis was performed to calculate the hazard ratio and the 95% confidence interval. All potential confounders were entered in a univariate analysis, and covariates with $p < 0.05$ were retested for multivariate analysis. The best cut-off value of the Selvester QRS score was determined using the receiver operating characteristic (ROC) curve for cardiac events. Survival curves were estimated by the Kaplan–Meier method. The cardiac event-free rates were compared between the groups by the log-rank test. Spearman's rank correlation coefficient was used to examine the relationship of the Selvester QRS score with CVF. A *p*-value of <0.05 was considered statistically significant.

Results

Baseline characteristics

Baseline patient characteristics are shown in Table 1. Of all 91 patients, 66 (73%) were men, and the mean age was 53 years. Eighty-six (95%) patients were classified as having New York Heart Association functional (NYHA) class I or II. LV ejection fraction was 32 ± 9% and the plasma BNP level was 80 (43–237) pg/mL. The Selvester QRS scores of all patients were distributed from 0 to 14 points, with a mean of 4.1 points (Fig. 1). The detailed characteristics of the QRS score for each ECG type in our population are shown in Table 2. In 15 patients with LBBB, 10 (67%) patients had abnormal findings meeting the scoring criterion in aVF, 12 (80%) patients in V_1, and 13 (87%) patients in V_2. By contrast, no patients fulfilled the criteria in II or aVF in RBBB, LAFB, or LAFB with RBBB. In 35 patients with LV hypertrophy, 25 (71%) patients satisfied the criterion in V_4. In addition, approximately 40% of the

Table 1
Baseline characteristics.

	All patients (n = 91)
Age, years	53 ± 13
Male, n (%)	66 (73)
Body mass index, kg/m^2	23.2 ± 3.8
NYHA functional class, n (I/II/III)	46/40/5
Heart rate, bpm	78 ± 14
Systolic BP, mmHg	121 ± 21
Diastolic BP, mmHg	73 ± 14
Previous history, n (%)	
Prior hospitalization for HF	17 (19)
Hypertension	18 (20)
Diabetes mellitus	15 (16)
Dyslipidemia	18 (20)
Medical therapy	
ACEis/ARBs, n (%)	67 (74)
Beta-blockers, n (%)	61 (67)
MRAs, n (%)	47 (52)
Loop diuretics, n (%)	62 (68)
Laboratory measurements	
Hemoglobin, g/dL	14.4 ± 1.6
Sodium, mEq/L	139 ± 3
Albumin, g/dL	4.0 ± 0.3
Estimated GFR, mL/min/1.73 m^2	71.6 ± 22.7
BNP, pg/mL	80 (43–237)
Electrocardiography	
QRS duration, ms	116 ± 24
QRS voltage, mV	3.69 ± 1.60
Selvester QRS score, point	4.1 ± 3.3
Echocardiography	
Left atrial dimension, mm	40 ± 7
LV end-diastolic dimension, mm	64 ± 8
LV ejection fraction, %	32 ± 9
E/e'	15.4 ± 7.7
Cardiac catheterization	
Cardiac index, L/min/m^2	2.7 ± 0.6
PCWP, mmHg	12.6 ± 6.7
Endomyocardial biopsy	
Collagen volume fraction, %	3.34 ± 2.37

Data are presented as mean ± standard deviation, n (%), or median (interquartile range). Collagen volume fraction was assessed in 79 patients.
ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor II blocker; BNP, brain natriuretic peptide; BP, blood pressure; E/e', ratio of early transmitral flow velocity to early diastolic mitral annular velocity; HF, heart failure; GFR, glomerular filtration rate; LV, left ventricular; MRA, mineralocorticoid receptor antagonist; NYHA, New York Heart Association; PCWP, pulmonary capillary wedge pressure.

patients had abnormal findings in aVL, V_1, V_2, or V_3. The mean of CVF was 3.34%.

Cardiac events during the follow-up period

The follow-up period was 4.5 ± 3.2 years. A total of 20 cardiac events occurred, including one cardiac death, 16 hospitalizations for worsening HF, and three lethal arrhythmias. In univariate Cox regression analysis for cardiac events, systolic blood pressure, hemoglobin level, serum sodium level, plasma BNP level, pulmonary capillary wedge pressure, the ratio of early transmitral flow velocity to early diastolic mitral annular velocity, the Selvester QRS score, and CVF were selected as significant determinants (Table 3). Subsequently, multivariate Cox regression analysis revealed that the QRS score (hazard ratio, 1.32; 95% confidence interval, 1.05–1.67; p = 0.02), BNP level (hazard ratio, 5.17; 95% confidence interval, 1.46–18.35; p = 0.011), and pulmonary capillary wedge pressure (hazard ratio, 1.10; 95% confidence interval, 1.01–1.19; p = 0.03) were independent determinants of cardiac events.

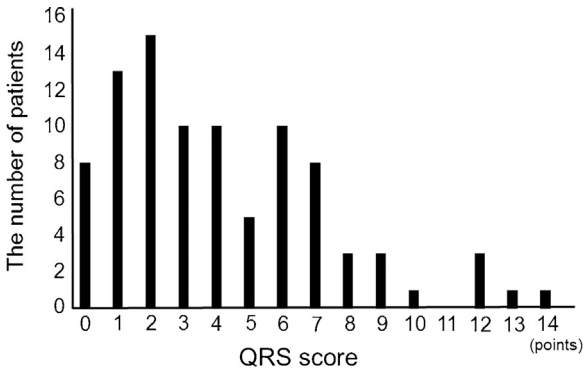

Fig. 1. Distribution of the Selvester QRS score. The minimum, median, and maximum QRS scores were 0, 3, and 14 points, respectively.

Cut-off value of the Selvester QRS score

We performed ROC analyses to assess the clinical utility of the Selvester QRS score for predicting future cardiac events in NIDCM patients. The best cut-off value was determined as 3 points, with 85% sensitivity and 47% specificity (area under the curve 0.688, p = 0.011) (Fig. 2A). Next, we divided patients into two groups based on the best cut-off value of the Selvester QRS score as follows: high score group (HS group, >3 points) and low score group (LS group, ≤3 points). Baseline characteristics of the groups are shown in Table 4. There were no significant differences between the two groups except for the Selvester QRS score. Kaplan–Meier survival analyses revealed that the cardiac event rate was significantly higher in the HS group than in the LS group (log-rank, p = 0.011) (Fig. 2B). The detailed contents of cardiac events are shown in Table 5.

Correlation of the Selvester QRS score with CVF

The CVF of EMB samples was measured in 79 patients to examine the association of the Selvester QRS score with myocardial interstitial fibrosis. The CVF was significantly higher in the HS group (4.22%) than in the LS group (2.45%) ($p < 0.001$) (Table 4). Further, there was a significant positive correlation of the Selvester QRS score with CVF (r = 0.46, $p < 0.001$; Fig. 3).

Discussion

The main findings of the present study were that the Selvester QRS score was an independent determinant of cardiac events in patients with NIDCM, and was positively correlated with CVF in EMB samples. Although an association of the Selvester QRS score with poor outcome or amount of myocardial scar was previously reported in a small number of patients with myocardial infarction or cardiac sarcoidosis [15,16,22], to our knowledge, this is the first report in NIDCM patients.

Prognostic value of the Selvester QRS score

In the present study, we examined the use of resting 12-lead ECG for risk stratification in NIDCM patients. Our results demonstrated that a 1-point increase of the Selvester QRS score was associated with a 1.32-fold higher risk of cardiac events. ECG findings such as LBBB, prolonged QRS duration, and QRS voltage were previously reported to have prognostic value in NIDCM patients [23–27]. However, although each ECG finding is useful for predicting future cardiac events, the value of these findings is limited. This is because a comprehensive understanding of ECG findings is necessary for clinical risk stratification. In the present study, only 15 (16%) patients presented with LBBB, while 16 (21%) of the remaining 76 patients without LBBB experienced cardiac events during the follow-up period. Further, although a prolonged QRS duration was reported to be associated with systolic

Table 2
Characteristics of the Selvester QRS score.

Abnormal lead	LBBB ($n=15$)	RBBB ($n=3$)	LAFB ($n=2$)	LAFB+RBBB ($n=1$)	LVH ($n=35$)	No confounders ($n=35$)
I, *n* (%)	1 (7)	1 (33)	1 (50)	1 (100)	4 (11)	15 (43)
II, *n* (%)	4 (27)	0 (0)	0 (0)	0 (0)	2 (6)	3 (9)
aVL, *n* (%)	3 (20)	2 (67)	1 (50)	1 (100)	16 (46)	16 (46)
aVF, *n* (%)	10 (67)	0 (0)	0 (0)	0 (0)	4 (11)	8 (23)
V_1 Ant., *n* (%)	12 (80)	0 (0)	0 (0)	0 (0)	2 (6)	4 (11)
V_1 Post., *n* (%)	0 (0)	2 (67)	0 (0)	1 (100)	12 (34)	12 (34)
V_2 Ant., *n* (%)	13 (87)	0 (0)	0 (0)	0 (0)	13 (37)	4 (11)
V_2 Post., *n* (%)	0 (0)	2 (67)	0 (0)	1 (100)	3 (9)	5 (14)
V_3, *n* (%)	–	1 (33)	0 (0)	0 (0)	13 (37)	10 (29)
V_4, *n* (%)	–	1 (33)	0 (0)	1 (100)	25 (71)	27 (77)
V_5, *n* (%)	8 (53)	2 (67)	0 (0)	1 (100)	2 (6)	24 (69)
V_6, *n* (%)	2 (13)	2 (67)	0 (0)	1 (100)	2 (6)	17 (49)
QRS score, point	4.5 ± 2.6	5.7 ± 5.7	1.0 ± 1.4	12	3.3 ± 2.2	4.7 ± 3.9

Data are presented as mean ± standard deviation or *n* (%).
Ant., anterior; LAFB, left anterior fascicular block; LBBB; left bundle branch block; LVH, left ventricular hypertrophy; Post., posterior; RBBB, right bundle branch block.

Table 3
Cox proportional hazard regression analysis for cardiac events.

	Univariate analysis		Multivariate analysis	
	HR (95% CI)	*p*	HR (95% CI)	*p*
Age	0.98 (0.95–1.01)	0.17		
Male	0.47 (0.19–1.16)	0.10		
Systolic BP	0.97 (0.95–1.00)	0.03	0.98 (0.94–1.01)	0.23
Hemoglobin	0.75 (0.56–1.00)	0.04	0.95 (0.57–1.56)	0.83
Sodium	0.82 (0.69–0.97)	0.02	0.94 (0.78–1.15)	0.56
Log BNP	5.63 (2.21–14.36)	<0.001	5.17(1.46–18.35)	0.011
PCWP	1.09 (1.03–1.16)	0.006	1.10 (1.01–1.19)	0.03
ACEis/ARBs	1.26 (0.42–3.79)	0.68		
Beta-blockers	1.53 (0.56–4.22)	0.41		
MRAs	1.91 (0.76–4.78)	0.17		
LV ejection fraction	0.98 (0.92–1.03)	0.36		
E/*e*′	1.07 (1.01–1.13)	0.02	1.08 (1.00–1.16)	0.054
QRS duration	1.01 (0.99–1.03)	0.31		
QRS voltage	0.92 (0.67–1.26)	0.60		
LBBB	1.17 (0.39–3.50)	0.78		
Selvester QRS score	1.26 (1.11–1.42)	<0.001	1.32 (1.05–1.67)	0.02
Collagen volume fraction	1.33 (1.11–1.60)	0.002	1.00 (0.73–1.36)	0.99

ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor II blocker; BNP, brain natriuretic peptide; BP, blood pressure; CI, confidence interval; *E*/*e*′, ratio of early transmitral flow velocity to early diastolic mitral annular velocity; HR, hazard ratio; LBBB, left bundle branch block; LV, left ventricular; MRA, mineralocorticoid receptor antagonist; PCWP, pulmonary capillary wedge pressure.

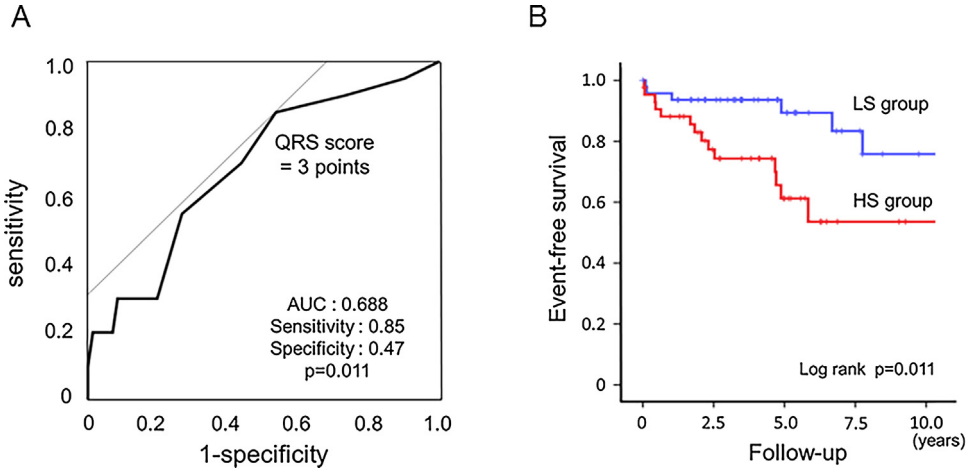

Fig. 2. Cut-off value of the Selvester QRS score for cardiac events. The best cut-off value of the QRS score was 3 points (A). The cardiac event rate was significantly higher in the high score (HS) group (red line) than in the low score (LS) group (blue line) (B). AUC, area under the curve.

Table 4
Comparison of patient characteristics between the two groups.

	LS group ($n=46$)	HS group ($n=45$)	p
Age, years	54 ± 12	51 ± 12	0.22
Male, n (%)	35 (76)	31 (69)	0.44
Body mass index, kg/m^2	23.3 ± 3.7	23.3 ± 3.9	0.92
NYHA functional class, n (I/II/III)	25/19/2	21/21/3	0.73
Heart rate, bpm	75 ± 11	79 ± 15	0.12
Systolic BP, mmHg	120 ± 21	121 ± 21	0.87
Diastolic BP, mmHg	73 ± 16	72 ± 11	0.72
Previous history, n (%)			
Prior hospitalization for HF	8 (17)	9 (20)	0.75
Hypertension	12 (26)	6 (13)	0.13
Diabetes mellitus	7 (15)	8 (18)	0.74
Dyslipidemia	8 (17)	9 (20)	0.75
Medical therapy			
ACEis/ARBs, n (%)	32 (70)	35 (78)	0.37
Beta-blockers, n (%)	30 (65)	31 (69)	0.71
MRAs, n (%)	20 (43)	27 (60)	0.11
Loop diuretics, n (%)	31 (67)	31 (69)	0.88
Laboratory measurements			
Hemoglobin, g/dL	14.3 ± 1.4	14.5 ± 1.7	0.60
Sodium, mEq/L	140 ± 2	139 ± 3	0.21
Albumin, g/dL	4.0 ± 0.4	4.1 ± 0.3	0.45
Estimated GFR, mL/min/1.73 m^2	67.7 ± 15.9	75.6 ± 27.5	0.10
BNP, pg/mL	65 (35–187)	104 (58–285)	0.60
Electrocardiography			
QRS duration, ms	113 ± 21	119 ± 25	0.21
QRS voltage, mV	3.94 ± 1.59	3.43 ± 1.59	0.13
Selvester QRS score, point	1.6 ± 1.0	6.8 ± 2.6	<0.001
Echocardiography			
Left atrial dimension, mm	40 ± 6	40 ± 8	0.57
LV end-diastolic dimension, mm	63 ± 8	65 ± 7	0.28
LV ejection fraction, %	33 ± 8	31 ± 9	0.34
E/e'	15.6 ± 9.0	15.2 ± 6.4	0.83
Cardiac catheterization			
Cardiac index, L/min/m^2	2.7 ± 0.6	2.7 ± 0.7	0.78
PCWP, mmHg	11.4 ± 5.7	13.7 ± 7.5	0.10
Endomyocardial biopsy			
Collagen volume fraction, %	2.45 ± 1.56	4.22 ± 2.70	<0.001

Data are presented as mean ± standard deviation, n (%), or median (interquartile range). Collagen volume fraction were analyzed in 79 patients (LS group; $n=39$, HS group; $n=40$).
HS, high score; LS, low score; ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor II blocker; BNP, brain natriuretic peptide; BP, blood pressure; E/e', ratio of early transmitral flow velocity to early diastolic mitral annular velocity; HF, heart failure; GFR, glomerular filtration rate; LV, left ventricular; MRA, mineralocorticoid receptor antagonist; NYHA, New York Heart Association; PCWP, pulmonary capillary wedge pressure.

Table 5
Cardiac events in both groups.

	All ($n=91$)	LS group ($n=46$)	HS group ($n=45$)
Total events, n (%)	20 (22)	6 (13)	14 (31)
Cardiac death	1 (1)	0 (0)	1 (2)
Hospitalization for worsening heart failure	16 (18)	5 (11)	11 (24)
Lethal arrhythmia	3 (3)	1 (2)	2 (4)

HS, high score; LS, low score.

dysfunction or poor prognosis [13,28], the average QRS duration was 116 ms in our study, and the QRS duration was similar between the HS and LS groups. In addition, the mean QRS voltage was 3.69 mV, and was similar between the two groups. The fact that these prognostic predictors were comparable in our study may be attributed to two main reasons. First, the Selvester QRS score is a comprehensive scoring system based on a number of abnormal findings on ECG. Second, almost all patients in our study were relatively classified as early-stage NIDCM, with no or mild

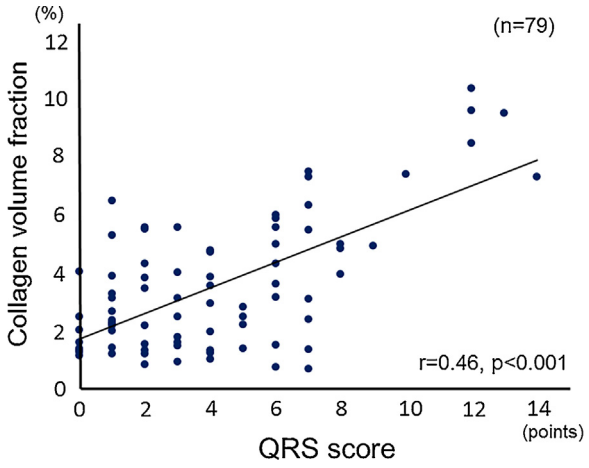

Fig. 3. Relationship between QRS score and collagen volume fraction.

symptoms of HF. Thus, we suggest that the QRS score provides a more comprehensive risk stratification, even in patients with early stage NIDCM.

Distribution and the optimal cut-off value of the QRS score in NIDCM

In the present study, the Selvester QRS score had a maximum of 14 points, although the median was 3 points, suggesting that the QRS score in NIDCM was distributed within a relatively low-score range. A previous study in patients with ST elevation myocardial infarction reported a median QRS score of 6 points [16], while a mean QRS score of 5.6 points was reported in LBBB patients following ischemic cardiomyopathy (ICM), which was higher than that in non-ICM patients (5.2 points) [29]. By contrast, the mean QRS score in cardiac sarcoidosis patients was reported as 3.1 points, with a best cut-off value obtained by ROC curve as 3 points [22], which was comparable to our results. As above, the differences in the QRS score between these studies may be attributed to the various etiologies in the subjects. Further, the majority of patients in our study had early-stage NIDCM with symptoms of HF classified NYHA functional class I or II. Indeed, Strauss et al. reported that the patients with more severe NYHA functional class had a higher QRS score [30]. However, as we demonstrated, the Selvester QRS score was a significant determinant of prognosis even in asymptomatic or mildly-symptomatic NIDCM patients.

Relationship between the QRS Score and CVF

The infarct size of myocardial ischemia was reported to have prognostic value [31], and the Selvester QRS score was originally developed to estimate the amount of myocardial scar in old myocardial infarction [14]. The myocardial abnormalities in ICM are typically characterized as replacement fibrosis or scar. However, the myocardial abnormalities in NIDCM are mainly characterized as interstitial fibrosis [32]. Interestingly, we found a significant correlation of the QRS score with myocardial fibrosis assessed as CVF in NIDCM patients. We showed the characteristics of the Selvester QRS score in each conduction abnormality (Table 2). However, to our best knowledge, there were no studies about the detailed findings of the Selvester QRS score in NIDCM. Sobue et al. also reported a relationship between the QRS score and the area of late gadolinium enhancement on cardiovascular magnetic resonance, which reflects myocardial fibrosis in cardiac sarcoidosis [22]. The detailed mechanisms of a correlation between the QRS score and myocardial fibrosis remains unclear

in NIDCM, but we surmise that the Selvester QRS score in NIDCM might reflect the electrophysiological and pathological changes of myocardial and interstitial tissues in the whole heart. Actually, the Selvester QRS scores one year later in some NIDCM patients were changed (data not shown). It may be attributed to the structural or functional changes accompanied by the progression of cardiac remodeling or successful reverse remodeling. Thus, we believe that the Selvester QRS scoring system could be applicable to both types of myocardial fibrosis: the reparative and regional fibrosis in ischemic cardiomyopathy and the reactive and interstitial fibrosis in nonischemic cardiomyopathy. We suggest that the Selvester QRS score, which is noninvasive and can be evaluated repeatedly using a resting ECG, may be useful for quantification of myocardial fibrosis in NIDCM.

Clinical implications and future perspectives

We investigated the association between the comprehensive ECG characteristics of the Selvester QRS score and future cardiac events in NIDCM, and found that the QRS score was related to the amount of myocardial fibrosis in EMB samples. Resting 12-lead ECG is a conventional standard examination that is cheap, noninvasive, reproducible, rapid, and usable anywhere, and also contains important clinical information for physicians. Our data suggest that the Selvester QRS score has potential for widespread clinical use to estimate myocardial condition and to predict cardiac events in NIDCM.

Study limitations

First, a limitation of our study was the small sample size of patients in a single center. Further studies with larger numbers of patients in multiple centers are required to validate our findings. Second, although the Selvester QRS score may change during the course of the observation, we could not assess that in this study. Third, although CMR imaging with late gadolinium enhancement or T1-mapping techniques can noninvasively quantify global myocardial fibrosis in NIDCM [33,34], we could not assess this by CMR. Nevertheless, we suggest that EMB techniques are invasive but useful methodologies to directly assess myocardial fibrosis. Finally, we could not clarify the detailed mechanisms of a correlation between the QRS score and myocardial fibrosis in this study.

Conclusions

The Selvester QRS score is useful to predict future cardiac events in NIDCM patients. In addition, this score is associated with the amount of myocardial fibrosis assessed by CVF in EMB samples.

Author's contributions

HH, TO, and AS conceived and designed this study. YS, TK, NW, SA, TI, KK, NK, K Fukaya, K Furusawa, and RM collected and analyzed data. HH, TO, AS, KT, YKB, and TM interpreted the results. HH, TO, AS, and TM drafted the manuscript.

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Conflict of interest

TO received research grants from Ono, Bayer, Tanabe Mitsubishi, and Daiichi Sankyo. RM belongs to a development endowed by Chugai, Kowa, Kyowa Hakko Kirin, MSD, Kureha, and Nippon Boehringer Ingelheim. KT received lecture fees and research grants from Bayer, Daiichi Sankyo, Pfizer, and Dainippon Sumitomo. YKB received lecture fees and research grants from AstraZeneca, Daiichi Sankyo, MSD, Takeda, and Tanabe Mitsubishi. TM received lecture fees and unrestricted research grant for the Department of Cardiology, Nagoya University Graduate School of Medicine from Astellas, Daiichi Sankyo, Dainippon Sumitomo, Kowa, MSD, Tanabe Mitsubishi, Nippon Boehringer Ingelheim, Novartis, Otsuka, Pfizer Japan, Sanofi-aventis, Takeda and Teijin. The other authors declare no conflict of interest.

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Corrigendum

Corrigendum to "The Selvester QRS score as a predictor of cardiac events in nonischemic dilated cardiomyopathy" [J. Cardiol. 71 (2018) 284–290]

Hiroaki Hiraiwa (MD)[a], Takahiro Okumura (MD, PhD)[a,*], Akinori Sawamura (MD, PhD)[a], Yuki Sugiura (MD)[a], Toru Kondo (MD)[a], Naoki Watanabe (MD)[a], Soichiro Aoki (MD)[a], Takeo Ichii (MD)[a], Katsuhide Kitagawa (MD)[a], Naoaki Kano (MD)[a], Kenji Fukaya (MD, PhD)[a], Kenji Furusawa (MD)[a], Ryota Morimoto (MD, PhD)[a,b], Kyosuke Takeshita (MD, PhD)[a,c], Yasuko K. Bando (MD, PhD)[a], Toyoaki Murohara (MD, PhD, FJCC)[a]

[a] Department of Cardiology, Nagoya University Graduate School of Medicine, Nagoya, Japan
[b] Department of CKD Initiatives Internal Medicine, Nagoya University Graduate School of Medicine, Nagoya, Japan
[c] Department of Clinical Laboratory, Nagoya University Hospital, Nagoya, Japan

There is an error in the section of methods of statistical analysis. Correctly, the covariates with $p < 0.01$ in univariate analysis were retested for multivariate analysis. In addition, Table 3 is incorrect. Please see the corrected Table 3 here.

Table 3
Cox proportional hazard regression analysis for cardiac events.

	Univariate analysis		Multivariate analysis	
	HR (95% CI)	*p*	HR (95% CI)	*p*
Age	0.98 (0.95–1.01)	0.17		
Male	0.47 (0.19–1.16)	0.10		
Systolic BP	0.97 (0.95–1.00)	0.03		
Hemoglobin	0.75 (0.56–1.00)	0.04		
Sodium	0.82 (0.69–0.97)	0.02		
Log BNP	5.63 (2.21–14.36)	<0.001	5.17 (1.46–18.35)	0.011
PCWP	1.09 (1.03–1.16)	0.006	1.10 (1.01–1.19)	0.03
ACEis/ARBs	1.26 (0.42–3.79)	0.68		
Beta-blockers	1.53 (0.56–4.22)	0.41		
MRAs	1.91 (0.76–4.78)	0.17		
LV ejection fraction	0.98 (0.92–1.03)	0.36		
E/e′	1.07 (1.01–1.13)	0.02		
QRS duration	1.01 (0.99–1.03)	0.31		
QRS voltage	0.92 (0.67–1.26)	0.60		
LBBB	1.17 (0.39–3.50)	0.78		
Selvester QRS score	1.26 (1.11–1.42)	<0.001	1.32 (1.05–1.67)	0.02
Collagen volume fraction	1.33 (1.11–1.60)	0.002	1.00 (0.73–1.36)	0.99

ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor II blocker; BNP, brain natriuretic peptide; BP, blood pressure; CI, confidence interval; *E/e′*, ratio of early transmitral flow velocity to early diastolic mitral annular velocity; HR, hazard ratio; LBBB, left bundle branch block; LV, left ventricular; MRA, mineralocorticoid receptor antagonist; PCWP, pulmonary capillary wedge pressure.

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* Corresponding author at: Department of Cardiology, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan.
E-mail address: takaoku@med.nagoya-u.ac.jp (T. Okumura).

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