Original Article
Retrospective analysis of time limit of QRS complex in the electrocardiogram and its clinical significance in patients with acute myocardial infarction

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Abstract: Objective: This study aimed to analyze the prognostic value of fragmented wide QRS (f WQRS) in patients with acute ST-segment elevation myocardial infarction (STEMI). Methods: Eighty-five STEMI patients treated in our hospital from September, 2016 to August, 2017 were selected as objects of study. The patients were divided into Group A (GA, n=15), Group B (GB, n=12), Group C (GC, n=12), Group D (GD, n=16), Group E (GE, n=11) and Group F (GF, n=19) according to results of the electrocardiogram (ECG). The six groups were detected and analyzed with respect to coronary artery lesions, invasion site, cardiac parameters, myocardial injure markers, Killip grading, and prognosis. Results: GA and GB had right coronary artery occlusion; GC mainly had right coronary artery occlusion and circumflex artery occlusion, and GD mainly had right coronary artery occlusion. The invasion site of GE was mainly in the proximal (middle) segment of anterior descending branch and that of GF in the (middle) distal segment of the anterior descending branch. Conclusion: Monitoring the phenomenon of QRS in ECG is an effective method to evaluate the disease condition and prognosis of STEMI patients. Therefore, this method shall be emphasized in clinical practice.

Keywords: Acute myocardial infarction, electrocardiogram, fragmented wide QRS, prognosis evaluation

Introduction

Acute myocardial infarction (AMI) is a common and frequently-occurring disease in the clinic. According to statistics, the incidence of AMI presents a rising tendency in recent years [1, 2]. Currently, electrocardiogram (ECG) examination is still an important auxiliary means in the clinical diagnosis of AMI. It is often found that there is a fragmented wide QRS (f WQRS) in ST-segment depression of correspondence leads during the diagnosis of ST-segment elevation myocardial infarction (STEMI), but this situation has not been fully emphasized in previous diagnosis [3, 4]. Overseas reports in recent years have shown that the phenomenon of QRS in STEMI patients may be associated with their prognosis [5]. This study was conducted to analyze the prognostic value of f WQRS in ECG among STEMI patients, thereby providing theoretical data support for clinical diagnosis.

Materials and methods

Clinical materials

Eighty-five STEMI patients treated in our hospital from September, 2016 to August, 2017 were selected as objects of study, including 43 men and 42 women, aged 42-78 years, with an average age of (62.46±11.29) years. Selection criteria [6]: Severe chest pain that lasted for more than 30 min without palliative effect from oral administration of nitroglycerine. There was a ST-segment elevation of ≥ 0.1 mv in limb leads in wall I or above or a ST-segment elevation of ≥ 0.2 mv in chest leads. The concentration of serum cardiac markers changed dynamically. Inclusion criteria: The clinical time was no more than 24 h. All the enrolled patients underwent coronary angiography (CAG). Exclusion criteria: This study excluded patients with a clinical time of more than 24 h; those who refused to receive CAG; those complicated by pulmonary

Table 1. Analysis of coronary artery lesions and invasion site of all groups: cases (%)

Group	Number of cases	Right coronary artery occlusion	Circumflex artery occlusion	Proximal (middle) segment of anterior descending branch	(Middle) distal segment of anterior descending branch	Other sites
GA	15	15 (100.00)	0 (0)	/	/	/
GB	12	12 (100.00)	0 (0)	/	/	/
GC	12	7 (58.33)	5 (41.67)	/	/	/
GD	16	10 (62.50)	6 (37.50)	/	/	/
GE	11	/	/	8 (72.73)	/	3 (27.27)
GF	19	/	/	/	11 (57.89)	8 (42.11)

embolism, cardiac rupture, aortic dissecting aneurysm, malignant tumor, acute cerebrovascular disease, disseminated intravascular coagulation, immune system disease, and abnormal renal and liver function; and those with a treatment history of STEMI. The 85 patients were divided into Group A (GA), Group B (GB), Group C (GC), Group D (GD), Group E (GE) and Group F (GF) according to ECG results. Thereinto, 15 patients in GA had elevation in inferior leads, complicated with depression in high lateral leads and anterior leads; 12 patients in GB had elevation in inferior leads, complicated by depression in high lateral leads; 12 patients in GC had elevation in inferior leads, complicated by depression in anterior leads; 16 patients in GD had elevation in inferior leads; 11 patients in GE had elevation in anterior leads, complicated by depression in inferior leads; and 19 patients in GF had elevation in anterior leads.

Methods

The clinical indicators and therapeutic status of enrolled patients were observed and recorded. ECG results and ultrasonic cardiogram (UCG) results were recorded in the acute stage. Levels of N-terminal pro B-type natriuretic peptide (NT-proBNP), cardiac troponin I (cTnI), creatine kinase (CK) and creatine kinase-MB (CK-MB) were recorded in peak period of incidence. The cardiac function was evaluated through NYHA grading. Grade I: there was no obvious symptom of heart failure. Grade II: there were obvious symptoms of heart failure and the pulmonary rales were less than 50% of the lung field. Grade III: the pulmonary rales were more than 50% of the lung field. Grade IV: the patient suffered from cardiac shock, with different degrees of hemodynamic changes. Patients were compared in CAG results, including left ventricular end-diastolic dimension (LVDD) and left ventricular ejection fraction (LVEF). Complications and deaths were recorded dur-

ing the hospitalization. This study has been approved by the Ethics Committee of Lianyungang TCM Hospital Affiliated to Nanjing University of Chinese Medicine. All patients and their families agreed to participate in the experiment and signed the informed consent form.

Observation targets

All groups were analyzed in respect of coronary artery lesions, invasion site, clinical indicators, and prognosis. The correlation was then analyzed in QRS of the ECG with disease condition and prognosis of STEMI patients.

Statistical analysis

Excel software was used for data management. Graphpad prism 8 was used for plotting statistical charts. Measured data were analyzed through t test. Enumerated data were analyzed through χ^2 test. $P < 0.05$ indicated a significant difference.

Results

Analysis of coronary artery lesions and invasion site of all groups

The proportion of patients with right coronary artery occlusion were respectively 100% (15/15) and 100% (12/12) in GA and GB. GC mainly had correspondence leads of right coronary artery occlusion and circumflex artery occlusion, accounting for 58.33% (7/12) and 41.67% (5/12), respectively. GD mainly had correspondence leads of right coronary artery occlusion and circumflex artery occlusion, accounting for 61.50 (10/16) and 37.50% (6/16), respectively. There was no significant difference in basic information and other complications among the six groups ($P > 0.05$), which indicated that the baseline data of each group had good equilibrium and comparability (**Table 1**).
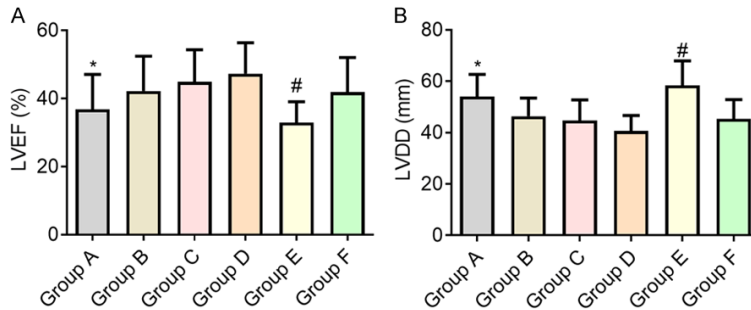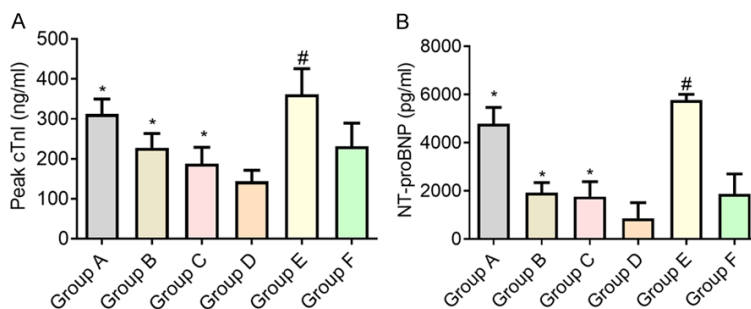
Figure 1. Comparison of cardiac measures among all groups. Note: *means *P* < 0.05 in comparison with Group D; and #means *P* < 0.05 in comparison with Group F. A: LVEF; B: LVDD. LVEF: left ventricular ejection fraction; LVDD: left ventricular end-diastolic dimension.
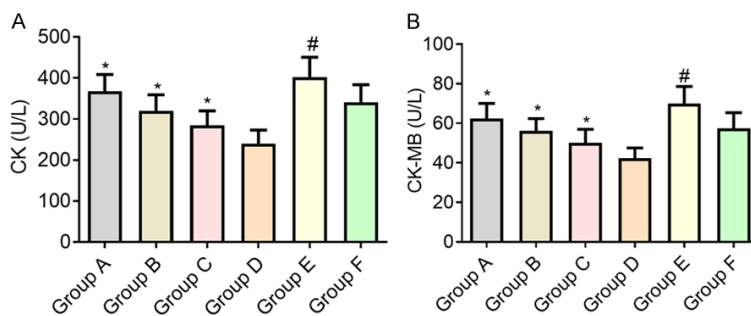
Figure 2. Comparison of CK and CK-MB levels among all groups. Note: *means *P* < 0.05 in comparison with Group D; and #means *P* < 0.05 in comparison with Group F. A: CK; B: CK-MB. CK: creatine kinase; CK-MB: creatine kinase-MB.

Figure 3. Comparison of cTnI and NT-proBNP levels among all groups. Note: *means *P* < 0.05 in comparison with Group D; and #means *P* < 0.05 in comparison with Group F. A: cTnI; B: NT-proBNP. cTnI: cardiac troponin I; NT-proB-NP: N-terminal pro B-type natriuretic peptide.

Comparison of cardiac measures among all groups

GA had lower LVEF and higher LVDD than GD, showing a statistical difference (*P* < 0.05). GB and GC had slightly lower LVEF and slightly higher LVDD than GD, showing no statistical difference (*P* > 0.05). GE had lower LVEF and higher LVDD than GF, showing a statistical differ-

ence (*P* < 0.05) (**Figure 1**). This suggested that the cardiac function impairment in STEMI patients with a QRS phenomenon was more serious.

Comparison of CK and CK-MB levels among all groups

The levels of CK and CK-MB in GA, GB, and GC were much higher than those in GD, showing statistical difference (*P* < 0.05). The levels of CK and CK-MB in GE were much higher than those in GF, indicating a statistical difference (*P* < 0.05) (**Figure 2**). This suggested that the levels of CK and CK-MB were higher in STEMI patients with QRS phenomenon.

Comparison of cTnI and NT-proBNP levels among all groups

The levels of cTnI and NT-proBNP in GA, GB, and GC were much higher than those in GD, showing a statistical difference (*P* < 0.05). The levels of cTnI and NT-proBNP in GE were much higher than those in GF, indicating a statistical difference (*P* < 0.05) (**Figure 3**). This suggested that the levels of cTnI and NT-proBNP were higher in STEMI patients with QRS phenomenon.

Comparison of Killip grading for cardiac function among all groups

The Killip grading of GD was milder than that of GA, GB, and GC; and that of GF was milder than that of GE, with a statistical difference (*P* < 0.05) (**Table 2**). This suggested that STEMI patients with QRS phenomenon had higher Killip grading.

Comparison of prognosis among all groups

The proportions of patients with left heart failure, cardiac shock, and cardiac death in GA,

Table 2. Comparison of Killip grading for cardiac function among all groups: cases (%)

Group	Number of cases	Grade I	Grade II	Grade III	Grade IV
GA	15	0 (0.00)	4 (26.67)	9 (60.0)	2 (13.33)*
GB	12	1 (8.33)	2 (16.67)	7 (58.33)	2 (16.67)*
GC	12	2 (16.67)	5 (41.67)	4 (33.33)	1 (8.33)*
GD	16	6 (37.50)	6 (37.50)	4 (25.0)	0 (0.00)
GE	11	0 (0.00)	3 (27.27)	7 (63.64)	1 (9.09)#
GF	19	2 (10.53)	7 (36.84)	10 (52.63)	0 (0.00)

Note: *means $P < 0.05$ in comparison with GD; and #means $P < 0.05$ in comparison with GF.

Table 3. Comparison of prognosis among all groups: cases (%)

Group	Number of cases	Left heart failure	Cardiac shock	Malignant arrhythmia	Cardiac rupture	Cardiac death
GA	15	5 (33.33)*	2 (13.33)*	1 (6.67)	1 (6.67)*	4 (26.67)*
GB	12	2 (16.67)*	2 (16.67)*	1 (8.33)	0 (0.00)	2 (16.67)*
GC	12	2 (16.67)*	2 (16.67)*	1 (8.33)	0 (0.00)	2 (16.67)*
GD	16	0 (0.00)	0 (0.00)	1 (6.25)	0 (0.00)	0 (0.00)
GE	11	3 (27.27)#	1 (8.33)#	1 (9.09)#	1 (9.09)	3 (27.27)#
GF	19	1 (5.26)	0 (0.00)	0 (0.00)	0 (0.00)	1 (5.26)

Note: *means $P < 0.05$ in comparison with GD; and #means $P < 0.05$ in comparison with GF.

Table 4. Analysis of correlation of QRS in ECG with disease condition and prognosis of STEMI patients

Item	Statistical value	Disease condition of STEMI patients	Prognosis of STEMI patients
QRS in ECG	r	0.811	0.758
	P	< 0.001	< 0.001

GB, and GC were much higher than that in GD, and the proportion of patients with cardiac rupture in GA was much higher than that in GD, showing a statistical difference ($P < 0.05$). The proportion of patients with malignant arrhythmia in GA, GB, and GC was higher than that in GD, and the proportion of patients with cardiac rupture in GC was higher than that in GD, but without statistical difference ($P > 0.05$). The proportions of patients with left heart failure, cardiac shock, malignant arrhythmia, and cardiac death in GE were much higher than that in GF, showing a statistical difference ($P < 0.05$) (**Table 3**).

Analysis of correlation of QRS with disease condition and prognosis of STEMI patients

According to Pearson correlation analysis, QRS was positively correlated with the disease con-

dition and prognosis of STEMI patients (**Table 4**). This suggested that QRS wave had a significant positive correlation with the condition and prognosis of STEMI patients.

Discussion

In clinical practice, the phenomenon of QRS often occurs in the ECG examination of STEMI patients. The incidence of this phenomenon is about 25%-65% [7-9]. In previous examinations of STEMI patients, relevant medical staff usually paid more attention to the detection value of ST-segment elevation in ECG, but ignored the effect of QRS [10, 11]. Overseas research in recent years has found that the phenomenon of QRS in ECG of STEMI patients may be closely related to the severity of disease and prognosis [12-15]. In consideration of few domestic reports about the diagnostic value of QRS phenomenon in STEMI patients, this paper focused on it so that clinicians could further understand or master the ECG of STEMI patients.

In this study, GA and GB had right coronary artery occlusion; GC mainly had right coronary artery occlusion and circumflex artery occlusion, and GD mainly had right coronary artery occlusion. The invasion site of GE was mainly located in the proximal (middle) segment of anterior descending branch and that of GF in the (middle) distal segment of the anterior descending branch. This implied that STEMI patients with a phenomenon of QRS had typical invasion sites or epidemiological features, which was basically consistent with the reports of Henderson et al. [16, 17]. Regarding disease condition and symptoms, the peak levels of cTnI, CK, CK-MB, and NT-proBNP in GA, GB, and GC were much higher than those in GD. LVEF of GA was lower than that of GD. The peak levels

of cTnI, CK, CK-MB, and NT-proBNP in GE were much higher than those in GF. LVEF of GE was much lower than that of GF. In addition, the Killip grading of GD was milder than that of GA, GB, and GC; and that of GF was milder than that of GE. These implied that the phenomenon of QRS in STEMI patients reflected a higher level of indicators related to infarct size, a severer disease condition, and a severer situation of cardiac function injury. As for prognosis, the proportion of patients with left heart failure, cardiac shock, and cardiac death in GA, GB, and GC was much higher than that in GD. The proportion of patients with cardiac rupture in GA was much higher than that in GD. The proportion of patients with left heart failure, cardiac shock, malignant arrhythmia and cardiac death in GE was much higher than that in GF. This showed that anterior myocardial infarction occurred in the proximal segment of the anterior descending branch and deviated towards the inferior myocardium in ST-segment. Therefore, the distance of inferior leads caused depression of ST-segment. Myocardial infarction occurred in the proximal segment of the anterior descending branch, which expanded the range of ischemic infarction and directly affected the normal operation of left ventricular function [18-20].

According to relevant data, patients with acute inferior myocardial infarction (AIMI) had a better clinical prognosis than those with acute anterior myocardial infarction (AAMI), but 50% of them suffered from complications, affecting the indicators of clinical prognosis [21, 22]. About 80%-90% of patients suffered from AIMI due to right coronary artery occlusion. They are complicated by ST-segment elevation in II, III, and avF leads. Some patients had artery occlusion in the left circumflex coronary artery [2]. The results showed that the incidence of RSTD in AIMI patients was higher than that in AAMI patients. This proved that the vasculopathy was severer and the ischemic area or infarct size was larger in AIMI patients [23, 24].

This study also has some shortcomings. Due to the short time of the study and small number of cases collected, it is a small sample size, which may introduce bias on the research results. In the next study, the sample size will be expanded.

In conclusion, monitoring the phenomenon of QRS in ECG is an effective method to evaluate the disease condition and prognosis of STEMI patients. This method shall be emphasized in clinical practice.

Disclosure of conflict of interest

None.

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References

[1] Tanriverdi Z, Colluoglu T, Unal B, Dursun H and Kaya D. The prognostic value of the combined use of QRS distortion and fragmented QRS in patients with acute STEMI undergoing primary percutaneous coronary intervention. J Electrocardiol 2018; 51: 210-217.

[2] Kurtul A and Duran M. Fragmented QRS complex predicts contrast-induced nephropathy and in-hospital mortality after primary percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction. Clin Cardiol 2017; 40: 235-242.

[3] Toukola T, Junttila MJ, Holmström LTA, Haukilahti MA, Tikkanen JT, Terho H, Kenttä TV, Aro AL, Anttonen O, Kerola T, Pakanen L, Kortelainen ML, Kiviniemi A and Huikuri HV. Fragmented QRS complex as a predictor of exercise-related sudden cardiac death. J Cardiovasc Electrophysiol 2018; 29: 55-60.

[4] Rönn F, Kesek M, Karp K, Henein M and Jensen SM. Right ventricular lead positioning does not influence the benefits of cardiac resynchronization therapy in patients with heart failure and atrial fibrillation. Europace 2011; 13: 1747-1752.

[5] Daly MJ, Adgey JA and Harbinson MT. Improved detection of acute myocardial infarction in patients with chest pain and significant left main stem coronary stenosis. QJM 2012; 105: 127-135.

[6] China Society of Cardiology of Chinese Medical Association, Editorial Board of Chinese Journal of Cardiology; China Society of Cardiology of Chinese Medical Association Editorial Board of Chinese Journal of Cardiology. Guideline on the diagnosis and therapy of ST-segment elevation myocardial infarction. Zhonghua Xin Xue Guan Bing Za Zhi 2015; 43: 380-393.

[7] Naruse Y, Silva M, Watanabe M, Venlet J and Zeppenfeld K. 218-06: fragmented QRS is associated with an increased risk of ventricular tachycardia recurrence and cardiac death af-

ter catheter ablation in ischemic heart disease. EP Europace 2016; 18: i187-i187.

[8] Barcan A, Suciu Z and Benedek I. Response to fragmented QRS complex predicts contrast-induced nephropathy and in-hospital mortality after primary percutaneous coronary intervention in patients with st-segment elevation myocardial infarction. Clin Cardiol 2017; 40: 1174-1175.

[9] Kucharz A and Kułakowski P. Fragmented QRS complex in patients with implantable cardioverter defibrillator-prevalence and predisposing factors. J Electrocardiol 2018; 51: 913-919.

[10] Misumida N, Kobayashi A, Saeed M, Fox JT and Kanei Y. Neutrophil-to-lymphocyte ratio as an independent predictor of left main and/or three-vessel disease in patients with non-ST-segment elevation myocardial infarction. Cardiovasc Revasc Med 2015; 16: 331-335.

[11] Vervaat FE, Christensen TE, Smeijers L, Holmvang L, Hasbak P, Szabó BM, Widdershoven JW, Wagner GS, Bang LE and Gorgels AP. Is it possible to differentiate between Takotsubo cardiomyopathy and acute anterior ST-elevation myocardial infarction? J Electrocardiol 2015; 48: 512-519.

[12] Takada A, Saito K, Murai T, Kurosaki K, Kurihara K and Hamamatsu A. Right ventricular free wall dissection as a rupture tract in left ventricular rupture during acute myocardial infarction. Leg Med (Tokyo) 2015; 17: 525-531.

[13] Cetin MS, Ozcan Cetin EH, Canpolat U, Cay S, Topaloglu S, Temizhan A and Aydogdu S. Usefulness of fragmented QRS complex to predict arrhythmic events and cardiovascular mortality in patients with noncompaction cardiomyopathy. Am J Cardiol 2016; 117: 1516-1523.

[14] Haukilahti MAE, Holmström L, Vähätalo J, Tikkanen JT, Terho HK, Kiviniemi AM, Lepojärvi ES, Tulppo M, Perkiömäki JS, Ukkola OH, Anttonen O, Aro AL, Kerola T, Rissanen H, Knekt P, Junttila MJ, Huikuri HV and Kenttä TV. Gender differences in prevalence and prognostic value of fragmented QRS complex. J Electrocardiol 2020; 61: 1-9.

[15] Xu Y, Ren T and Lian W. GW29-e1212 the effect of fragmented QRS complex on the left ventricular remodeling and heart function in patients with acute myocardial infarction in short-term and long-term. J Am Coll Cardiol 2018; 72: C138-C139.

[16] Henderson RA, Jarvis C, Clayton T, Pocock SJ and Fox KA. 10-year mortality outcome of a routine invasive strategy versus a selective invasive strategy in non-ST-segment elevation acute coronary syndrome: the British heart foundation RITA-3 randomized trial. J Am Coll Cardiol 2015; 66: 511-520.

[17] Peng W, Wang Y, Li X, Zheng J, Liu X, Zhang H, Yang P, Fu D, Hang Z, Zhou Y, Zhao X, Zhao G, Wang D, Yang K, Wang L and Zhao C. A retrospentive analysis of blood flow perfusion among coronary arteries during double vessel acute simultaneous occlusion in acute ST-elevation myocardial infarction patients. Chinese Journal of Emergency Medicine 2015; 24: 397-400.

[18] Tanriverdi Z, Besli F, Gungoren F, Begenc Tascanov M and Halil Altiparmak I. Frequency of fragmented QRS in patients with hypertension. Blood Press 2019; 28: 214.

[19] Tinazli M and Cerit L. Hyperuricemia and fragmented QRS. Gazzetta Medica Italiana Archivio per le Scienze Mediche 2019; 178.

[20] Genc A, Cetin S, Yüksek E, Tasdemir A, Akkuş M, Kalelioglu T, Genç ES, Karamustafalioglu N and Emul M. Schizophrenia and fragmented QRS. Eur Neuropsychopharmacol 2016; 26: S513-S514.

[21] Tachibana M, Morita H, Ueoka A, Miyoshi A, Tsushima S, Sugiyama H, Nakagawa K, Watanabe A, Nishii N, Nakamura K and Ito H. 177-02: QRS widening and fragmented QRS rise a risk of cardiac sarcoidosis in complete right bundle branch block patients. EP Europace 2016; 18: i181.

[22] Bokma JP, Winter MM, Vehmeijer JT, Vliegen HW, van Dijk AP, van Melle JP, Meijboom FJ, Post MC, Zwinderman AH, Mulder BJ and Bouma BJ. QRS fragmentation is superior to QRS duration in predicting mortality in adults with tetralogy of fallot. Heart 2017; 103: 666-671.

[23] Cho HJ, Yoon JY, Kim N, Jang SY, Bae MH, Lee JH, Yang DH, Park HS, Cho Y and Chae SC. Predictive value of a fragmented QRS complex in diagnosing patients with myocardial ischemia. Clin Cardiol 2019; 42: 379-384.

[24] Akboga MK, Yuksel M, Balci KG, Kaplan M, Cay S, Gokbulut V, Yayla C, Ertem AG, Ayhan MA, Topaloglu S and Aras D. Tp-e interval, Tp-e/QTc ratio, and fragmented QRS are correlated with the severity of liver cirrhosis. Ann Noninvasive Electrocardiol 2017; 22: e12359.