Prediction of Sudden Cardiac Death in Elderly Patients with Acute Myocardial Infarction with ST Segment Elevation, Having Undergone Myocardial Reperfusion by Percutaneous Coronary Intervention

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ABSTRACT

Prediction of fatal arrhythmias in acute myocardial infarction (AMI) is extremely important. Objective: Create a differential diagnostic model for predicting sudden cardiac death in elderly patients with STEMI with the history of PCI. Methods: We studied 152 patients (143 men and 9 women), mean age 70.3±3.4 years, with STEMI after PCI; EF LV less than 50%. The patients were divided into 2 groups: those who died on the first day from SCD and those who survived. The QT interval and its parts were measured upon admission and after PCI. The control group consisted of 30 healthy individuals. Results: A model was developed for determining the level of risk of arrhythmic death on the first day from SCD after successful PCI based on ECG criteria using DA. The most informative for the differential diagnosis was a set of the following indicators: QTd, QTapcd, and SubTd. The most significant indicator is Sub Td. The following algorithms were developed: ROAD = Qtd x 0.3438 + QTapcd x 0.0842 - SubTd x 0.0864 - 19.5068, NROAD = Qtd x 0.1997 - QTapcd x 0.0148 + SubTd x 0.3261 - 20.893. Their practical implementation on models is proved. Conclusion: The creation of a “ROAD/NROAD” differential diagnosis model for predicting SCD in patients with STEMI after PCI suggests practical application at the prehospital stage in this category of patients for prophylactically fatal VA and SCD. Assessment of the possible development of adverse events in patients with STEMI after PCI is possible using the ECG method based on the use of indicators such as QTd, QTapcd, and SubTd at the prehospital stage.

Keywords: acute myocardial infarction (AMI), ST-segment elevation myocardial infarction (STEMI), ventricular arrhythmias (VA), sudden cardiac death (SCD), percutaneous coronary intervention (PCI), discriminant analysis (DA).

INTRODUCTION

Cardiovascular disease (CVD) and acute myocardial infarction (AMI) are the leading cause of death among old people (Shekhovtsova et al. 2018a). The contribution of CVD to the total mortality rate of the Russian Federation is 57%. At the same time, the elderly population is an increasing proportion of patients admitted with AMI (Shekhovtsova et al. 2018b). The optimal management of these patients today remains an urgent problem due to the clinical features of this category of patients and the lack of specific scientific data, which increases the tendency to a more conservative treatment strategy (Orobtsova et al. 2018). The management tactics for STEMI is emergency reperfusion, and, according to the 2017 ESC recommendations (Poldervaart al. 2017), without limiting the upper age level (Anyfantakis et al. 2009). One of the most frequent AMI complications in old patients is ventricular arrhythmias (VA) and, as a result, sudden cardiac death (SCD) (Benjamin et al. 2017; Savilova et al. 2008).

Today, the question of the possibility of predicting fatal VA in patients with STEMI remains relevant, despite the restoration of coronary blood flow by percutaneous coronary intervention (PCI) (PCI) (Takada et al. 2019). The course of the early postoperative period is dangerous due to the development of fatal arrhythmias in this category of patients and initiates the continuation of the search for prognosis markers for the possibility of choosing high-risk patients and timely changing the treatment strategy (Mikhailov, et al. 2019; Kalenik et al. 2018; Günay et al. 2018).

It should be noted that there are a number of stratification models (scales) of risk (TIMI, GRACE, PURSUIT, etc.) that define risk groups with an assessment of its degree and choice of the method of pharmacotherapy, thereby reducing mortality (Savilova et al. 2008).

At the same time, these prognostic scales have a number of limitations, due to which they are not widely used in the everyday practice of Russian hospitals (Osipova et al. 2018). Among these limitations, the most significant is the low level of knowledge in the population of Russian patients, the inability to quickly determine all the components of the scale (for example, the level of biochemical markers of myocardial necrosis, creatinine during hospitalization, the determination of which takes time) (Takada et al. 2019). Of particular interest is the evaluation of data obtained at the prehospital stage in this category of patients, in particular, ECG criteria (Osipova et al. 2018; Osipova et al. 2018). Since, according to the Order of the Ministry of Health of the Russian Federation dated May 10, 2017 No. 203n "On the approval of criteria for assessing the quality of medical care" of all the used instrumental methods for examining a patient with ACS, the ECG recording is included in the standard of care for this pathology and has strictly regulated time frames for execution (Bonnemeier et al. 2001).

Thus, it seems important and relevant to search for a prognostic model that would be economically viable, simple and convenient for use in practical health care. Therefore, to create such a model, we chose ECG with an estimate of the QT interval and its components to use in our study.

OBJECTIVE

Create a differential diagnostic model for the "risk of arrhythmic death (ROAD)/no risk of arrhythmic death (NROAD)" for predicting sudden cardiac death in old patients with STEMI with the history of PCI.

MATERIALS AND METHODS

The results of 152 patients were studied. The examined patients were 143 (94.2%) men and 9 (5.9%) women, their average age was 71.1 [66-74], 70.3 ± 3.4 years. The criteria for inclusion in the study were: the presence of STEMI with an effective emergency PCI with stenting of a heart attack artery in the first 3 hours from the onset of the disease, ejection fraction (EF) of the left ventricle (LV) of the heart less than 50%. Patients were examined in two stages: upon admission, and on the 1st day of STEMI after PCI.

ECG was recorded according to the standard method in 12 leads at a speed of 50 mm/s.

The following intervals were determined on the ECG: QT (distance from the beginning of the Q wave to the end of the T wave), QTap (distance from the beginning of Q to the tip of the T wave), JT (distance from point J to the end of the T wave), JTap (distance from the point J to the top of the T wave), and SubT (distance from the top of the T wave to its end).

The measurements were taken with a standard measuring ruler in at least 3 consecutive cardiocycles in each lead. The smallest number of ECG leads in which an adequate measurement of QT was performed was 7.

Since the duration of the QT interval and its parts depend on the heart rate (HR), the Bazett formula was used for their correction: $QTc=QT/\sqrt{RR}$, $QTapc=QTap/\sqrt{RR}$, $JTc=JT/\sqrt{RR}$, $JTapc=JTap/\sqrt{RR}$, $SubTc=SubT/\sqrt{RR}$, where QTc, QTapc, JTc, JTapc and SubTc are the average values of the intervals QT, QTap, JT, JTap and SubT, respectively, corrected by the Bazett formula (s); QT, QTap, JT, JTap and SubT - average values of the intervals QT, QTap, JT, JTap and SubT (s); RR is the duration of the cardiac cycle (s).

Then, the variance of the QT interval and its parts was calculated: the difference between the maximum and minimum values of these intervals of the same standard ECG. The corrected variance of the QT interval and its parts was calculated as the difference between the maximum and minimum values corrected by the Bazett formula.

QTcd= QTc max-QTc min; QTapcd= QTapc max-QTapc min; JTcd= JTc max-JTc min; JTapcd= JTapc max-JTapc min; SubTcd= SubTc max- SubTc min.

Subsequently, patients were divided into 2 groups: 32 patients with STEMI after successful PCI, were in stable condition and died on the first day after successful revascularization from SCD, as well as 120 patients with STEMI who underwent PCI without early complications after revascularization.

The control group consisted of 30 healthy individuals, comparable in age and sex with STEMI patients.

RESULTS AND DISCUSSION

According to the number of risk factors, age, Killip severity grade, cardiac arrhythmias, potassium levels in the blood at admission, the dead and surviving patients were comparable. The average values of EF LV in the examined were 41.3 [20.4-49.0]%.

The practical implementation of the developed theory was aimed at creating a model of differential diagnosis of "ROAD/NROAD" conditions and discriminant analysis (DA).

The immediate task of DA is the selection of indicators for referring a new case to one or another group.

It was established that during hospitalization, the following indicators of the QT interval were reliably prolonged: QTm by 8.1% ($p<0.05$), QTcm by 18.1% ($p<0.000$), QTd by 142.86% ($p<0.000$), QTcd by 174.79% ($p<0.000$), QTapcm by 6.5% ($p<0.05$). It was proved that some indicators were shortened: the variance of the QTap interval (QTapd) was shorter by 60% ($p<0.000$), the QTapcd indicator by 55.2% ($p<0.000$), JTm by 17.3% ($p<0.005$), JTcm by 9.8% ($p<0.05$), JTapm by 37.5% ($p<0.000$) (Table 1).

Table 1: Electric physiological indicators at admission (Me[Mmin-Mmax])

Indicators, units of measurement	Study group (n=152)	Control group (n=30)	p
QTm, ms	435.0 [365.0-500.0]	402.3 [263.5-417.5]	0.01
QTcm, ms	489.3 [387.6-642.3]	414.4 [279.3-418.8]	0.000
QTd, ms	85.0 [50.0-130.0]	35.0 [30.0-40.0]	0.000
QTcd, ms	97.0 [51.8-162.6]	35.3 [32.0-46.5]	0.000
QTapcm, ms	328.3 [214.0-435.0]	308.2 [178.6-328.3]	0.02
QTapd, ms	10.0 [5.0-75.0]	25.0 [18.0-30.0]	0.000
QTapcd, ms	11.7 [4.6-91.6]	26.1 [18.4-32.0]	0.000
JTm, ms	332.5 [267.5-407.0]	402.2 [263.4-417.4]	0.002

JTcm, ms	373.7 [283.0-498.0]	414.3 [279.2-418.7]	0.02
JTd, ms	85.0 [50.0-130.0]	16.0 [11.0-21.0]	0.000
JTcd, ms	97.0 [51.8-162.6]	16.5 [12.1-22.1]	0.000
JTapm, ms	187.5 [107.5-269.5]	300.2 [168.4-324.9]	0.000
SubTm, ms	141.9 [117.0-221.0]	101.3 [85.0-125.0]	0.000
SubTcm, ms	163.2 [118.0-297.7]	104.0 [85.9-136.0]	0.000
SubTd, ms	75.0 [45.0-105.0]	16.0 [10.0-20.0]	0.000
SubTcd, ms	81.7 [46.7-133.4]	16.0 [10.2-21.0]	0.000

In turn, the indicators of the final segment of the QT interval in the general group of STEMI patients were higher than those of the control group: JTd was 5 times higher ($p<0.005$), JTcd was 5.8 times higher ($p<0.005$), SubTm prevailed by 40.1% ($p <0.005$), SubTcm by 56.9% ($p<0.005$), SubTd was 4.7 times higher (368.8%) ($p<0.005$), and SubTcd was 5.1 times higher (410.6%) ($p<0.005$).

Prediction was carried out by constructing new variables (linear combinations of the selected part of the primary indicators) and evaluating their numerical values.

According to the results of applying DA to the set of indicators listed above, the most informative for differential diagnosis was the set of the following indicators: QTd, QTapcd, SubTd (Table 2).

Table 2: The results of DA differential diagnosis of the ROAD/NROAD level

Indicator, units of measurement	Wilks' Lambda	Partial Lambda	F-femove (1.104)	p-value	Toler.	1-Toler (R-Sqr.)
QTd, ms	0.168375	0.887646	13.1638	0.000444	0.615776	0.384224
QTapcd, ms	0.163576	0.913690	9.8241	0.002239	0.821170	0.178830
SubTd, ms	0.387819	0.385380	165.8638	0.000000	0.713311	0.286689

Based on the obtained DA data, a matrix of the structural factor is determined (Table 3).

Table 3: Structural factor matrix (correlation variables – canonical roots).

Indicator, units of measurement	Root 1	p
QTd, ms	-0.089757	p<0.0000
QTapcd, ms	-0.515361	p<0.0000
SubTd, ms	0.772239	p<0.0000

The first column of the table shows the -Wilks values for each variable, which should be interpreted as the opposite of the general -Wilks: the more is, the more desirable is the presence of the indicator in the procedure. Considering this feature, the influence of all the selected indicators is quite comparable with the dominant contribution of Sub Td. Sub Td was proved to be more significant.

The inverse classification matrix characterizes the quality of the constructed algorithm and contains information about the number and percentage of observations correctly classified based on it in each group (Table 4).

Table 4: Classification of DA differential diagnosis of the ROAD/NROAD level

Group	Percent Correct	G_1:0 p=.29630	G_2:1 p=.70370
G_1:0	100.0000	32	0
G_2:1	98.6842	1	75
Total	99.0741	33	75

The data obtained show that the proposed model provides 100% sensitivity (of the 32 dead, the constructed model identified all patients) and 98.7% of the specificity of the method. This result is high enough for studies focused on indicators in medicine. The DA data are presented in Table 5.

Table 5: DS classification functions (Model 1).

Indicators	Classification functions	
	G_1:0	G_2:1
QTd, ms	0.3438	0.1997
QT apcd, мс	0.0842	-0.0148
Sub Td, мс	-0.0864	0.3261
Constant	-19.5068	-20.8930

Shown: column 1 for the "0 - ROAD" forecast and column 2 for the "NROAD" forecast). In our work, we developed the ROAD algorithm:

ROAD = Qtd x 0.3438 + QTapcd x 0.0842 - SubTd x 0.0864 – 19.5068, and NROAD algorithm:

NROAD = Qtd x 0.1997 – QTapcd x 0.0148 + SubTd x 0.3261 – 20.893.

The proposed algorithm is easy to implement.

CONCLUSION

VA and SCD are usually caused by AMI and are associated with an unfavorable clinical outcome (Benjamin et al. 2017; Shekhovtsova et al. 2018).

It was proved that the risk of irreversible myocardial ischemia, facilitating the development of focal or non-focal arrhythmogenic sources degenerating in VA, was the highest for 72 hours (Task et al. 2018).

Patients with STEMI are at high risk for life-threatening VA, hemodynamic instability. However, these high-risk SCD patients are not represented in randomized trials, and reliable data on their long-term prognosis are limited.

Accordingly, the recommendations of international guidelines are not uniform for patients with VA-complicated STEMI (Poldervaart et al. 2017; Savilova et al. 2008). In our study, differences in prognostic results are evaluated depending on the presence of risk factors and ECG indicators, which is used in the strategy of prehospital tactics of managing these patients (Takada et al. 2019). This study demonstrates that the strongest risk factors for SCD on the first day were QTd, QTapcd, SubTd, LV EF <35%.

The creation of a "ROAD/NROAD" differential diagnosis model for predicting SCD in old patients with STEMI after PCI suggests practical application at the prehospital stage in this category of patients for prophylactically fatal VA and SCD.

Thus we can state that the assessment of the possible development of adverse events in patients with STEMI after PCI is possible using the ECG method based on the use of indicators such as QTd, QTapcd, and SubTd at the prehospital stage (Task et al. 2018).

CONFLICT OF INTEREST: Nil

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