Available online at www.sciencedirect.com

ScienceDirect

Journal of Electrocardiology 48 (2015) 809–814

JOURNAL OF Electrocardiology

www.jecgonline.com

Assessment of electrocardiographic parameters in patients with electrocution injury

Mehmet Baran Karataş, MD,[a] Tolga Onuk, MD,[a] Barış Güngör, MD,[a,*] Göktürk İpek, MD,[a] Kazım Serhan Özcan, MD,[b] Mustafa Kaplangöray, MD,[c] Yiğit Çanga, MD,[d] Gündüz Durmuş, MD,[e] Yasin Çakıllı, MD,[a] Osman Bolca, MD[a]

[a] *Department of Cardiology, Siyami Ersek Thoracic and Cardiovascular Surgery Center, Training and Research Hospital, Istanbul, Turkey*
[b] *Department of Cardiology, Derince Training and Research Hospital, Kocaeli, Turkey*
[c] *Department of Cardiology, Şanlıurfa Mehmet Akif İnan Training and Research Hospital, Sanlıurfa, Turkey*
[d] *Department of Cardiology, Kartal Yavuz Selim Hospital, Istanbul, Turkey*
[e] *Department of Cardiology, Arnavutköy State Hospital, Istanbul, Turkey*

Abstract

Background: Electrocution injury (EI) is a major problem in developing countries. The aim of this study is to investigate the effect of EI on electrocardiographic (ECG) parameters.
Methods: A total of 43 patients hospitalized with diagnosis of EI were prospectively enrolled. Admission ECGs were compared with follow-up ECGs obtained one month after the event.
Results: Maximum P wave duration (Pmax), minimum P wave duration (Pmin), P wave dispersion (PWD), PR interval, QRS complex duration, corrected QT duration (QTc), QT dispersion (QTD), T peak to T end (Tp-e) interval were longer and Tp-e interval/QT and Tp-e interval/QTc ratios were higher on admission ECGs compared to follow-up ECGs. Frontal QRS-T angle and frequency of patients with fragmented QRS were also higher on admission ECGs.
Conclusion: Our study revealed that EI causes significant deterioration of admission ECG parameters. The clinical use of these parameters in prediction of arrhythmias after EI warrants further studies.

Keywords: Arrhythmias; Electrocardiography; Electrocution injury

Introduction

Electrocution injury (EI) is a trauma with a high morbidity and mortality. Cardiopulmonary arrest is a rare manifestation of EI and skin burns are the major complaint in most of the cases. Atrial and ventricular arrhythmias, myocardial injury, central nervous system and gastrointestinal system complications may also occur as a result of EI [1,2]. Particularly, cardiac damage of electrical current may be dramatic and may cause mortality [2,3]. Electrocardiography (ECG) is an important diagnostic tool for arrhythmias and is obtained in all patients with EI. However, the effect of EI on ECG parameters has not been investigated in detail.

In recent years, new ECG parameters such as P wave dispersion (PWD), QT dispersion (QTD), T peak to T end (Tp-e) interval, Tp-e interval/QT ratio, Tp-e interval/corrected QT ratio, frontal plane QRS-T angle and fragmented QRS (fQRS) have been defined. The predictive value of these parameters for atrial and ventricular arrhythmias has been shown in various studies [4–8]. In this study, we aimed to investigate the effect of EI on ECG parameters.

Methods

Study population

We prospectively enrolled 50 consecutive patients with EI who were hospitalized between January 2012 and December 2013 in Mehmet Akif İnan Training and Research Hospital. Exclusion criteria were patients younger than 18 years old, who were admitted >1 hour after EI; with previous diagnosis of coronary artery disease, congestive heart failure, severe valvular heart disease, chronic obstructive pulmonary disease, end-stage renal insufficiency and use of antiarrhythmic drugs. In addition subjects who had ECGs showing left/right bundle branch block pattern, pacemaker rhythm, pre-excitation syndromes, atrial fibrillation and whose ECGs were not suitable for calculation of

* Corresponding author at: Mehmet Akif Mah, Hicret Sok. Merit Life Bulvar Sit., A1/3 Umraniye, Istanbul, Turkey.
E-mail address: drbarisgungor@gmail.com

http://dx.doi.org/10.1016/j.jelectrocard.2015.06.009
0022-0736/

study parameters were excluded from the study. One patient with permanent atrial fibrillation, 2 patients with bundle branch blocks and 4 patients with other exclusion criteria were excluded from the study. Finally, a total number of 43 patients were included in the study. The study was approved by the local ethics committee and written informed consents were obtained from the study participants according to the Declaration of Helsinki.

Study protocol

Demographic and clinic features, voltage of electrical current, admission laboratory parameters, 4th hour troponin I, echocardiographic characteristics, hemodynamic findings were recorded. Cardiac monitoring was performed to all patients in the emergency unit. After initial evaluation, patients who had soft tissue damages were referred to burn care unit where they were treated by general surgeons. Hemodynamically instable patients were treated in the intensive care unit. Admission ECGs and follow-up ECGs which had been obtained 1 month after discharge were collected for electrocardiographic assessment.

Venous blood samples were taken from antecubital vein, collected in calcium EDTA tubes and were studied by an auto-analyzer (Cell-dyn 3700 Abbott, USA) during the emergency admission. Echocardiographic study was performed in the emergency department by Vivid 3 system (General Electric Company, Milwaukee, WI, USA) in accordance with the American Society of Echocardiography guidelines.

Hypertension was defined as a systolic pressure > 140 mmHg and/or a diastolic pressure > 90 mmHg or if the individual was taking antihypertensive medications. Diabetes mellitus was defined as a fasting glucose level > 126 mg/dl and/or if the patient was taking anti-diabetic medication. Hyperlipidemia was defined as total serum cholesterol levels > 240 mg/dL. Body mass index (BMI) was calculated by dividing weight into the square of height. High voltage injury was defined as EI patients exposed to electrical current above 1000 volts [3,9].

Electrocardiographic assessment

The 12-lead surface ECG (40 Hz, 50 mm/s, 10 mm/mV, Cardiofax GEM; Nihon Kohden Corp., Tokyo, Japan) was recorded at rest in the supine position. Electronic digital caliper was used to minimize the error measurements on the surface ECG. All ECGs were analyzed by an independent clinician who was blinded to the clinical data of the patients. Three measurements were done for each ECG parameter on 12 leads (except for Tp-e interval which was measured on precordial leads) and the mean of the three measurements was recorded. The longest value of each ECG parameter in any single lead was used in the statistical analysis.

P max was defined as the longest and P min as the shortest P-wave duration measured from the 12-lead ECG. P wave dispersion was defined as the difference between P max and P min [4]. PR interval was measured from the onset of the P wave to the onset of the QRS complex and values above 200 ms were accepted abnormal [10]. QRS complex duration was defined as the duration from the initial of the Q wave to the end of the S wave and values above 120 ms were accepted abnormal [10]. The QT interval was measured from the first deflection of the QRS complex to the end of the T wave defined as the meeting point of the descending branch of T to the isoelectric line, and was corrected for heart rate using the Bazett formula: $QTc = QTd\sqrt{}$ (R–R interval). Upper limit of QTc has been accepted as 440 ms in the literature [10]. The QTD was defined as the difference between the maximum and minimum QT interval of the 12-leads [11].

The Tp-e interval was defined as the interval from the peak of T wave to the end of T wave, and was corrected for heart rate. Measurements of Tp-e interval were performed from precordial leads [12]. Tp-e interval/QT and Tp-e interval/QTc ratios were calculated from these measurements.

The frontal plane QRS-T angle is defined as an angle between mean QRS axis and mean T axis that lies in the frontal plane of the body [6]. Angles above 60° were accepted abnormal in the analyses [10]. The fQRS was defined as the presence of an additional R wave (R′) or notching of R or S wave or the presence of fragmentation (more than one R') in at least two contiguous leads corresponding to a major coronary artery territory [13].

Although pathological cut-off values of novel ECG parameters are controversial in the literature, we determined some cut-off values according to the previous studies. We accepted PWD > 40 ms, QTD > 50 ms, Tp-e interval > 80.5 ms, Tp-e interval/QT > 0.210, Tp-e interval/QTc > 0.180 as abnormal [14–16].

Statistical analysis

All data are presented as a mean ± SD or a median (interquartile range) for parametric variables and as percentages for categorical variables. Continuous variables were checked for the normal distribution assumption using Kolmogorov–Smirnov statistics. Categorical variables were tested by Pearson's χ^2 test and Fisher's exact test. Admission and follow-up ECG data were compared using the paired t-test (for parameters with normal distribution) or the Wilcoxon signed-rank test (for parameters without normal distribution). For comparison between independent groups, independent-samples t-test or Mann–Whitney U test were used. A p value <0.05 was considered statistically significant. All statistical studies were carried out using Statistical Package for Social Sciences software (SPSS 16.0 for Windows, SPSS Inc., Chicago, IL).

Results

Demographic, clinical, laboratory and echocardiographic characteristics of the study group are summarized in Table 1. The study population consisted of 43 EI patients with a mean age of 31.5 ± 11.9 years. Seventy-seven percent (n = 33) of the patients were male. Sixty-three percent (n = 27) of the patients were exposed to high-voltage current. Mean systolic blood pressure of the patients on hospital admission was 123 ± 20 mm Hg, while heart rate was 86 ± 17 bpm. On admission laboratory analysis, white blood cell (WBC) counts were increased in 42% of patients (n = 18). Troponin