Available online at www.sciencedirect.com
ScienceDirect
Ecotoxicology and Environmental Safety 72 (2009) 885–888
Ecotoxicology and Environmental Safety
www.elsevier.com/locate/ecoenv

ECG alteration due to prolong exposure to natural gas leakage containing sulfur compounds in polluted areas of Masjid-I-Sulaiman (south of Iran) ☆

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Received 2 September 2006; received in revised form 13 December 2007; accepted 15 December 2007
Available online 19 February 2008

Abstract

This study was performed on 89 female healthy students with mean age 17 years who have lived in sulfur compounds contaminated areas of Masjid-I-Sulaiman (MIS). In order to determine the effects of sour gas containing sulfur compounds on some electrical activity of the heart, electrocardiogram was recorded. QT_c interval, PR interval, QRS complex and total sum of bipolar limb leads amplitude of R waves were analyzed and compared to standard values by using *one sample t-test* at $P<0.05$ as the significant level.

The results showed that PR interval and R amplitude were less than those of standard values. However, QT_c interval and QRS complex were not significantly different from their normal values. It can be concluded that chronic exposure to sour gas containing hydrogen sulfide contaminated air may provoke alterations of electrical activity of the heart.

Keywords: Sulfur compounds; QT_c; PR interval; R amplitude; QRS complex

1. Introduction

Masjid-I-Sulaiman (MIS) is located in the Khozestan Province southwest of Iran where the first oil well excavated in 1908 by William Darcy. Unfortunately, some areas of MIS have polluted atmosphere which is contaminated by subsurface leakage of sulfur compounds such as hydrogen sulfide (H_2S), SO_2, etc. The gas dissolved in the oil of MIS pools contains 40% H_2S (Saadat et al., 2004a). H_2S is referred to as a broad spectrum toxicant, and the nervous system is regarded as the primary target organ (Reiffenstein et al., 1992). Endogenous production of H_2S by mammalian tissues such as brain and vessels has suggested its physiological role on the cardiovascular system (Zhao et al., 2001; Tang et al., 2006). But answer to this question, 'chronic exposure to H_2S contaminated air has beneficial or harmful effect on the heart' has not been explored yet. It should be noted that H_2S beneficial and protective effects are related to its endogenous and physiological concentration (Geng et al., 2004). In our previous investigations hematological and some probable cardiovascular effects of sour gas containing H_2S have been reported (Saadat et al., 2004a, b).

Considering the above noted reports, the present study was performed to determine probable harmful effects of chronic exposure to sour gas containing H_2S on the heart. So, the study was started with electrocardiography of young female residents who were living in sour gas contaminated areas of MIS.

2. Methods

This study was performed on 89 healthy young female students with mean ages 17 years who were living in sour gas containing H_2S contaminated areas of MIS. The amount of all reactive sulfur compounds in air of the contaminated areas of MIS that can produce sulfate using

☆ This study was supported by Shiraz University (Grant no. 84-GR-SC-40) and was conducted in accordance with Iranian national guidelines for the protection of human welfare.
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doi:10.1016/j.ecoenv.2007.12.014

lead peroxide has been estimated to 0.023 ± 0.0002 ppm of SO_2 (Saadat et al., 2004b).

This study is a part of a bigger project which is entirely performed on females to investigate their more extensive physiological parameters such as sex hormones, respiration, etc. Also, this comments that some ECG parameters, especially, QRS voltage and duration are gender specific has been noticed (Clark et al., 2006).

The volunteers had neither anxiety due to measurements nor history of cardiovascular diseases. The local ethics committee approved the study. The electrocardiograms of the above-mentioned female students were recorded at rest through skin electrodes by a 12 leads Cardimax FX-2111 model ECG at paper speed of 25 mm/s and 1 mV/cm calibrated. In accordance with some recommendations for clinical QT interval and QRS complex measurement, these parameters were measured for three randomly selected consecutive beats through leads II and V_4. Each QT interval was measured from the beginning of the QRS complex to the visual return of the T wave to isoelectric line (Okin et al., 1998).

QT_c interval: The corrected QT (QT_c) was calculated using Bassett's formula in which QT interval was adjusted for heart rate (Toivonen, 2002; Al-Khatib et al., 2003; Moss, 1993):

$$QT_c = QT\,(s)/\sqrt{R - R\,(s)}.$$

Total sum of limb leads R amplitude: The voltage of R waves in three standard bipolar limb leads were measured from peak of R waves to the bottom of S waves. Then the sum of voltages of all the R waves were calculated (Goldberger, 2001).

PR interval was obtained from standard limb leads (Okin et al., 1998; Kamath et al., 2006).

The normal values of the above-mentioned parameters were obtained from 107 female student of Shiraz (non-contaminated areas southwest of Iran), which was 16–18 years old. These subjects had been studied previously by similar methods as a M.Sc. student thesis. The average of these values was very close to the standard values (Goldberger, 2001).

3. Data analysis

The data included QT_c, QRS complex; PR interval and total sum of limb leads R amplitude, were analyzed with SPSS for Windows (version 11.0). Data are presented as means $\pm$ SEM. The *one sample t-test* was used to compare the means with normal values.

A *P-value* $\leqslant 0.05$ was considered to indicate statistical significance.

4. Results

The mean $\pm$ SEM of P–R intervals, QT_c, QRS complexes and total sum of limb leads R amplitudes have been shown in Table 1. As it shows, P–R interval is 0.1454 ± 0.002 s, which is significantly less than its normal value (0.16 s) [$P < 0.001$]. Also total sum of limb leads R amplitudes is 2.23 ± 0.06 mV that is smaller than its normal value (4 mV) [$P < 0.001$]. However, QT_c is 0.441 ± 0.003 s, which is not significantly different from its normal value (0.44 s) [$P = 0.685$]. Finally, QRS duration is 0.078 ± 0.001 s, which is not different from its normal value (0.08 s) [$P = 0.44$].

It should be noted that shape changes neither in QRS complex nor in T wave were observed in any recorded electrocardiograms.

5. Discussion

Firstly, some technical limitations of this study that may influence the results should be noted. Electrocardiography and treadmill exercise testing is one of the most common noninvasive diagnostic methods for detecting heart diseases. These methods are familiar to most clinicians and are not routinely available for researchers. Therefore, in the present study electrocardiograms were recorded at rest.

The present findings and those of others (Zhao et al., 2001; Tang et al., 2006) suggest that prolonged H_2S exposure can provoke cardiovascular responses which can be monitored by electrocardiography. In Table 1 it has been demonstrated that total sum of limb leads R amplitude (voltage) is significantly less than its normal value. Low voltage of ECG (R amplitude) is a complex indicator which is allowing a number of mechanisms that are potentially contributing to cardiopulmonary disorders (Kamath et al., 2006; Louridas et al., 1982).

Amongst these mechanisms, changes in lung functions, myocardial ischemia and right ventricular hypertrophy are likely to dominate; but the effects improve of such alterations on ECG has been evidenced by the fact that low voltage R (amplitude) accompanies QRS prolongation and T wave inversion (Okin et al., 1998; Kamath et al., 2006). On the other hand, reduced lung functions, sever circulatory and respiratory disturbances upon inhalation of H_2S or prolong exposure to sulfur compounds have been reported (Richardson, 1995). Our results is not completely consistent with these mechanisms based on myocardial impairments, because surprisingly in present obtained results, neither QT prolongation nor changed shape of QRS have been observed. The mechanisms that underlie

Table 1
ECG parameters changes of female students who were living in H_2S contaminated areas of MIS

ECG parameters	*N*	Mean	Standard error	Normal value	*t*	*P*
PR interval (s)	89	0.145	0.06	0.16	−5.31	<0.001*
QRS duration (s)	89	0.078	0.001	0.08	−0.776	0.44
QT_c (s)	89	0.441	0.003	0.44	0.407	0.68
Total sum of limb leads R amplitude (mV)	89	2.23	0.06	4.00	−29.06	<0.001*

*Significantly different from normal value.