CORONARY ARTERY DISEASE AND T WAVE INVERSIONS IN ELECTROCARDIOGRAM AT HIGH ALTITUDE

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ABSTRACT

Objective: To find out the role of coronary artery disease (CAD) as a cause of T wave inversions in electrocardiogram (ECG) in otherwise healthy soldiers who were evacuated from high altitude because of chest pain.

Study Design: A prospective observational study

Place and duration of study: The study was carried out at CMH Skardu from September 2003 to September 2004

Patients and Methods: fifty-four consecutive patients evacuated from height > 4000 meters (13123 feet) with symptoms of chest pain and electrocardiographic changes of T-wave inversions in a group of leads were included in the study. Echocardiography and Exercise tolerance test (ETT) was performed on all the patients. All of the patients with indeterminate or inconclusive results on ETT underwent coronary angiography at Armed Forces Institute of Cardiology, Rawalpindi.

Results: Out of 54 patients, 36 (66.7%) patients had normal exercise tolerance test. In the rest 18 (33.34%) patients coronary angiogram was done and in 04 patients it was reported abnormal. In 02 (3.70%) patients coronary angiogram confirmed coronary artery disease. In 02 patients coronary angiograms were abnormal but there was no evidence of coronary artery disease.

Conclusion: T wave inversions at high altitude suggestive of IHD are not true indicators of underlying coronary artery disease.

Key words: ECG, coronary angiogram, high altitude, ETT

INTRODUCTION

Since ancient times, people have viewed mountain peaks as towering objects of myth, spiritual inspiration, and romantic beauty. Mountaineering as a sport was born on August 8, 1786, with the first ascent of Mont Blanc (4807 m), Europe's tallest peak. Since that ascent, mountain climbing is on the rise despite the awareness of health hazards associated with it. At high altitude the composition of air remains same as at sea level but the barometric pressure falls, resulting in alveolar hypoxia and increased ventilation [1]. At high altitude cardiac output for a given work level is the same in acclimatized subjects as at sea level. Although the coronary blood flow is decreased but coronary arterial oxygen extraction is increased to maintain myocardial oxygen delivery [2]. Myocardial contractility is not impaired by severe hypoxia (3). Due to alveolar hypoxia there is a decrease in systemic blood pressure while pulmonary arterial pressure is increased [4-6]. Hypobaric hypoxia causes vasoconstriction of pulmonary artery [7]. Polycythemia [8] strenuous physical work and vasoconstrictive effects of cold [9] further aggravate pulmonary hypertension. Prolong stay at high altitude induces thickening of the pulmonary arteriolar walls [10]. Ascent to extreme altitude without an artificial oxygen supply did not cause electrocardiographical signs of myocardial hypoxia [11].

Studies have been done to investigate the correlation between the coronary artery disease (CAD) and high altitude [12]. In the West most of these studies were done at moderate altitude in elderly patients already known to have CAD [13]. As a result of

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Siachin Glacier conflict young previously healthy individuals were exposed to the effects of high altitude [14]. Shafiq et al reported that coronary artery disease remains the major cause of death at high altitude among these individuals [15]. Doctors providing medical care to the individuals serving at high altitude bear the responsibility to identify those at risk of having CAD by the clinical history, bed side examination, simple laboratory tests and above all by the interpretation of ECG. ECG changes ranging from Q wave infarcts to right bundle branch block, right ventricular strain and T wave inversions are common among troops deployed at high altitude. Doctors serving at field/ base hospitals in northern areas find it easy to refer cases with ECG evidence of Q wave infarction to tertiary care hospital for evaluation as most of them are found to have CAD on subsequent investigations. However they are not sure of the reason for the T wave inversions in ECG among a large number of previously healthy soldiers reporting to them with chest pain. Two landmark studies were published in Armed Forces Medical Journal in 1994 to address this issue [16, 17] but since then little work has been done to find a correlation of ECG changes with underlying coronary artery disease in symptomatic but previously healthy adults. We thus carried out the this study to find out the occurrence of CAD in previously healthy individuals who were evacuated from high altitude with chest pain and T wave inversions in ECG.

PATIENTS AND METHODS

This prospective observational study was carried out in the northern area of Pakistan from September 2003 to September 2004.

Patients

Fifty-four consecutive patients evacuated from height > 4000 meters (13123 feet) to Armed Forces Institute of Cardiology, Rawalpindi due to chest pain and T wave negativity (inversions) in a set of ECG leads were included in the study. Exclusion criteria were: 1) ST segment elevation or depression. 2) LBBB 3) cardiac arrhythmias 4) obvious valvular lesion. An informed consent was obtained from all the patients included in the study. The study population, being serving soldiers, consisted of male only and was very heterogeneous as they belonged to all parts of the country.

Methods

On arrival at northern areas of Pakistan all the troops were physically evaluated. All these soldiers were physically healthy and their base line investigations including blood complete picture, Urine RE and ECG were normal. After acclimatization according to a set protocol they climbed to their respective posts at high altitude. The posts were in areas of perennial snow with night temperature between -12 to -40°C. They were evacuated from the posts to the field hospitals once they developed chest pain. At field hospitals (Altitude between 2800-3000 meters) they were physically examined and investigated (CBC, urine RE, Cardiac enzymes, ECG and Chest X-Ray PA view) by the medical officer/medical specialist. After the initial management these patients were then evacuated to the base Hospital at Skardu where a consultant physician evaluated them and additional tests (Renal functions, blood sugar, lipid profile and plasma-d-dimer assays) were done. Electrocardiogram was done on all the patients, first at field hospital and then at base hospital. ECG was read and interpreted by two independent observers. Patients with persistent T wave negativity on ECG were then transferred to Armed forces institute of cardiology (AFIC) Rawalpindi. At AFIC beside echocardiography all the patients underwent exercise tolerance test according to Bruce protocol. The results of the test were

reported as either normal (negative for ischemia) or abnormal (positive for ischemia); indeterminate or inconclusive. An abnormal response was defined as 1 mm or more horizontal or down sloping ST-segment depression (J point +80 ms) in any lead except aVR [18]. Up-sloping or junctional ST-segment changes, T-wave abnormalities, conduction disturbances, and ventricular arrhythmias that developed during exercise were considered indeterminate test. Negative exercise tests in which the heart target rate (85 % of maximal heart rate for age) is not achieved were considered non-diagnostic [19]. All patients with abnormal, indeterminate or inconclusive exercise tolerance test (ETT) underwent coronary angiography.

Statistical Analysis:

The data was compiled and analyzed by using SPSS software, version 10.

RESULTS

Age Analysis: The mean age of the patients was 29.33 years (SD ± 6.27) and a range of 20-42 years.

Clinical features: Fifteen (27.8 %) patients presented with typical history of ischemic chest pain (central chest pain compressive in nature and radiating to left arm), while 39 (72.2%) patients presented with atypical chest pain.

Duration of stay at post and evacuating time: The mean stay of these soldiers at high altitude was 50 days (range 02 to 180 days). A total of 23 (41.81%) patients stayed for less than 30 days while 06 (11.1%) patients stayed for more than 90 days. Mean time of evacuation from the posts to field hospital after the onset of chest pain was 4.94 days (SD ± 4.81) while mean time of evacuation from field hospital to the tertiary care centre (AFIC) was 7.81 days (SD ± 3.36).

Hemoglobin and blood chemistry: The mean hemoglobin after evacuation from high altitude was 17.50 g/dl (SD ± 1.882). ESR and Peripheral blood film including white blood cells, platelets were normal. Cardiac enzymes, fasting and random blood sugar, serum urea, creatinine, electrolytes and lipid profile were all within normal range.

Table 1: ECG groups based on ECG changes in a set of leads

ECG groups	1 (V1-V4)	2 (V1-V6)	3 (v4-V6)	4 (Multiple)	5 (11,111,avf)
Patients Number (%)	20 (37.0%)	6 (11.1%)	3 (5.6%)	7 (13.0%)	18 (33.3%)
T wave depth in mm (mean ± SD)	3.20±1.47	4.0±2.28	1.67±0.58	2.86±1.68	1.56±0.92
P wave height in mm (mean ± SD)	1.92±0.40	1.5±0.54	1.33±0.57	1.28±0.26	1.11±0.27
Mean QRS axis (Degrees)	91±26.98	88.33±34.30	43.3±64.2	58.5±42.98	65.28±9.15
R>S, or rsR in lead V1 Number (%)	6 (30%)	0	1 (33.3%)	0	1 (5.6%)

Table 2: Result of echocardiograms in different according to the ECG groups

ECG GROUP	No. of cases	Normal Echo	Dilated RV	Hypokinetic LV	Valve lesion
1(V1-V4)	20	17	3	0	0
2 (V1-V6)	6	2	1	1	2*
3(V4-V6)	3	3	0	0	0
4(Multiple)	7	6	0	0	1**
5(11,111,avf)	18	18	0	0	0

* *Trace MR, and Trace AR*

** *Mitral leaflet prolapse*

Table 3: Results of Coronary angiogram in different according to ECG groups

ECG Group	Patients	Coronary angiogram outcome		
		Normal	CAD	Abnormal
1(V1-V4)	5	3	1a	1c
2 (V1-V6)	5	3	1b	1d
3(V4-V6)	2	2	0	0
4(Multiple)	2	2	0	0
5(11,111,avf)	4	4	0	0

a; critical disease LAD

ECG: There was no significant abnormality in heart rate, PR, QRS and QT-intervals in the ECG of 54 patients. For the purpose of analysis of different ECG parameter, patients were placed in 5 arbitrary ECG groups based on T-wave negativity in a set of limb or precordial leads (Table 1).

Chest radiography: 02 (3.7%) patients had cardiomegaly (Cardiothoracic ratio more than 0.5%). None of the patient had pulmonary edema.

Exercise tolerance test (ETT): in 36 (66.7%) patients ETT was normal; while in 18 (33.33%) patients it was indeterminate or inconclusive.

Echocardiography: Echocardiogram was performed on all the patients. Forty-six (85.25%) patients had normal echocardiogram. 04 (7.4%) patients were having dilated right ventricle and out of these one patient was having mild tricuspid regurgitation. Echocardiogram was abnormal in 4 (7.4%) more patients. The detail of echocardiography findings (Table 2).

Coronary angiogram: Coronary angiogram was done in 18 (33.3%) patients in whom the ETT was indeterminate or inconclusive. In the rest of the cases (n-36, 66.66%) coronary angiogram was not done as clinical data and ETT did not favor the possibility of CAD. In 18 patients in whom coronary angiogram was done 04 patients were found to have abnormal angiogram. Two patients were confirmed to have CAD, one was having critical disease in the left anterior descending artery while the other was having re-canalized left anterior descending artery (LAD). Two more angiograms were abnormal but there was no evidence of underlying CAD. One patient had an aberrant origin of left coronary artery from the right coronary artery while the second patient had a tight muscle bridge in the LAD and a systolic squeeze of 40%. A relation of positive coronary angiogram with the ECG groups (Table 3).

DISCUSSION

In this study, only two patients were confirmed to have coronary artery disease. First patient had critical disease in the left anterior descending artery. He was 40 years old, a smoker and had known risk factors for IHD. This patient had ischemic chest pain at an altitude of 5456 meters (17900 feet) after staying there for 87 days. ECG showed T-wave inversion in leads V1-V4. Physical examination, cardiac enzymes, chest X-Ray and echocardiogram were within normal limits. This patient might have underlying coronary artery atherosclerosis even before he went to the post and high altitude might have compromised his coronary artery blood flow reserve [20] thus explaining his symptom and ECG changes.

In the second patient coronary angiography showed re-canalized left anterior descending artery. This patient had typical ischemic chest pain after staying at an altitude of 6096 meters (20000 feet) for 112 days. ECG showed T-wave inversion in leads V1-V6. This patient had no risk factors for ischemic heart disease. Echocardiography showed hypokinesia of anterior wall of left ventricle. His hemoglobin was 19.5 gm/dl and platelet count 250,000 /cmm. Prolonged stay at high altitude leads to polycythemia, increase in platelet count, and enhance platelet adhesiveness and an increase in risk of coagulation due to increase in clotting factor activity [21, 22]. Although we lack objective evidence of increased platelet adhesiveness and increased risk of coagulability but these factors might have contributed to the thrombotic event in this patient.

There were two patients, who had abnormal coronary angiogram, but did not fit in the category of CAD. One had aberrant origin of left coronary astery (LCA) from right coronary astery (RCA). The second patient had muscle bridge in the LAD with 40% systolic squeeze.

Stay at high altitude leads to pulmonary hypertension and right ventricular hypertrophy. Most commonly encountered ECG changes at high altitude include right-axis deviation and an R/S ratio equal to or greater than 1 in V1, with an R wave 0.5 mV or greater, right bundle branch conduction disturbances, increased T negativity in V1 and V2 and increase in P wave amplitude in inferior leads. Most changes reverted to normal within 12 hours of return to sea level, with the exception of the frontal-plane axis and T-wave alterations [23, 24]. On the basis of these studies we consider that most of the ECG changes in rest of our patients are due to pulmonary hypertension and do not signify underlying CAD. For the purpose of analysis and discussion we made five ECG groups but otherwise they didn't have any clinical significance. Out of 54 patients in our study 20 patients had T wave inversion in right

precordial leads (V1-V4). Only two patients had abnormal angiograms and in 18 patients there was no evidence of CAD. The mean QRS-axis was 91 degrees (SD ± 26.98) and in 6 patients there was either R>S or rsR pattern suggesting right ventricular hypertrophy or strain. Echocardiogram was done at tertiary centre few days after decent from high altitude (mean time of evacuation from field hospital to the tertiary care centre was 7.81 days, SD ± 3.36) thus echocardiogram showed dilated RV in only three patients. I. S. Anand et al. reported T-wave inversions in leads V1-V6 in 21 patients due to pulmonary hypertension [25]. This finding could explain T-wave negativity in patients of ECG group 2 (V1-V6) and 4 (multiple).

There were 18 patients with T wave inversions in inferior leads. The mean depth of T wave negativity was only 1.56 (SD ± 0.92) mm, range 1-4 mm. mean P wave amplitude was 1.111 (SD ± 0.274) mm range 1-2 mm and mean QRS axis was 65.28 (SD ± 9.15) degree range 50-85. Only one patient had partial right bundle branch block. All these patients had normal echocardiograms. In four patients angiograms were done and found normal. These minor ECG changes restricted to the inferior leads are unlikely to be due to pulmonary hypertension and are most likely insignificant.

CONCLUSION

Chest pain and T-wave inversions are common among soldiers serving at high attitude. These changes are mostly due to pulmonary hypertension and rarely caused by coronary artery disease.

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