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Overdamping of Styli of Printer can Perse Produce ST Segment Deviation Simulating of Myocardial Ischemia during Exercise Electrocardiography

Case Report

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Abstract

We observed four cases whose treadmill test gave an impression of significant exercise-induced myocardial ischemia. All tests were performed on one particular treadmill stress test system. All cases showed slow upsloping ST-segment depression in leads II, III, aVF, V5 and V6. Leads aVR, aVL, V1 and V2 showed ST-segment elevation. However, all the patients were asymptomatic and did not have any of the conventional cardiovascular risk factors. Family history was not contributory. Echocardiographic examination was normal. Patients did not develop any symptoms or any other evidence of myocardial ischemia during exercise and recovery. On reviewing raw electrocardiograms, we observed that these ST-segment changes were also present in resting supine electrocardiograms of all cases. Electrocardiograms recorded from another ECG machine did not show any ST-segment deviation seen during the treadmill test. These observations gave us the clue that ST-segment deviations seen during a treadmill test, were due to over-damping of styli of the printer of a particular treadmill system. Failure to recognize this possibility can result in the wrong diagnosis of significant exercise-induced myocardial ischemia.

keywords: Coronary artery disease; Electrocardiography; Exercise electrocardiography; Ischemic heart disease; Treadmill test

Introduction

Upsloping ST-segment which is one mm or more below the isoelectric line, 80 msec after J point, is considered as slow upsloping ST segment [1,2]. Slow upsloping ST-segment which is 1.5 mm or more below the isoelectric line, 80 msec after J point, is considered indicative of myocardial ischemia during exercise electrocardiography [3-5]. Exercise-induced ST-segment elevation of 0.5 mm in leads aVR and V1 is indicates left main or ostial LAD stenosis [6-8]. Isolated ST-segment elevation in lead V1 suggests stenosis of LAD prior to the first diagonal [5]. Significance increases if there in exercise-induced ST-segment elevation in lead aVR as well as in lead V1 [5,9]. Concomitant ST-segment depression in other leads further supports the diagnosis of significant myocardial ischemia [5,10]. Over-damping of the stylus is known to produce false ST-segment depression in leads with QRS having terminal S wave [11]. We have observed four cases where over-damping of styli produced ST-segment deviation during exercise electrocardiography.

Case Report

Case -1

A treadmill test was performed on a 45-year-old female as a part of a routine check-up. She did not have any history of angina or angina equivalent symptoms. She did not have any conventional cardiovascular risk factors. Family history was not contributory. Echocardiographic examination was normal. The resting pulse rate was 103/minute. Resting supine blood pressure was 140/80 mmHg. Cardiac examination was normal. The patient could exercise for six minutes (4.6 METs). The Peak heart rate was 153 beats/minute. Peak blood pressure was 170/80 mmHg. Review of raw ECG recorded during exercise (Figure 1 Exer) and recovery (Figure 1-recovery) showed slow upsloping ST-segment depression in leads II, III, aVF, V5 and V6 (marked). There was mild ST-segment elevation in leads aVR and V1 (marked). This created a doubt of exercise-induced myocardial ischemia. However, there were no symptoms during stress and recovery. There were no other electrocardiographic signs of myocardial ischemia. Subsequently, we noticed that these ST-segment

changes were also present in the resting ECG (Figure 1- Rest). We also noticed that these changes were not present in the average beats that were printed at the same time but from different styli (Figure 2). We suspected that the ST-segment deviations present in the raw ECG recorded during treadmill testing were probably due to some fault in the printer. We immediately recorded an electrocardiogram from another ECG machine. It did not show any ST-segment abnormality (Figure 3). It confirmed our suspicion that the ST-segment deviations seen in the electrocardiogram during stress and recovery were due to a damping problem with the styli of the particular treadmill system.

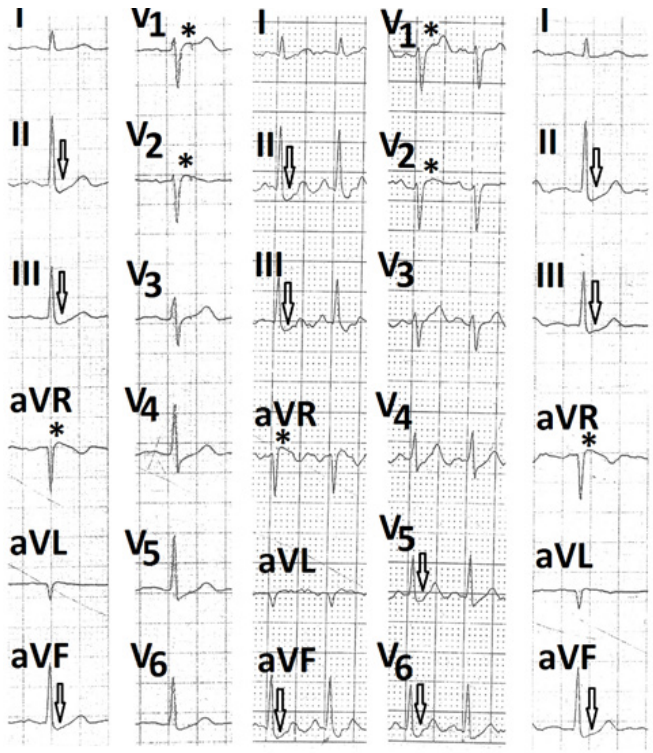

Figure 1: Raw electrocardiogram recorded during treadmill test showing slow upsloping ST-segment depression in leads II, III, aVF, V5 and V6 (marked) and mild ST-segment elevation in leads aVR and V1 (marked) at rest, during exercise (exer.) and during recovery.

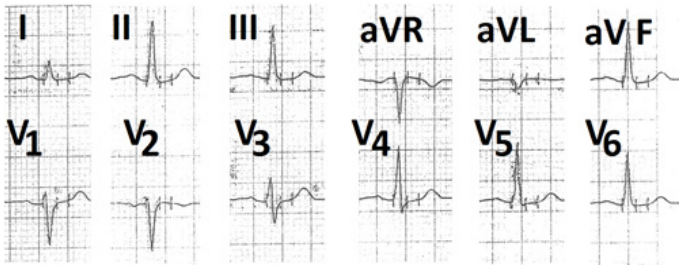

Figure 2: Averaged beats, at rest, printed from different styli showing no ST-segment deviations.

Case -2

A treadmill test was performed on a 52-year-old male for atypical chest pain. Cardiac examination was normal. Echocardiographic examination was normal. The resting pulse rate was 77 beats/minute. Resting supine blood pressure was 140/90 mm Hg. Resting supine electrocardiogram recorded from the treadmill printer showed slow upsloping ST-segment depression in leads II, III, aVF, V5 and V6 (Figure 4 -Rest –marked). Leads aVR, aVL, V1 and V2 showed ST-segment elevation (marked). Once again, averaged beats recorded from different styli did not show these ST-segment abnormalities (Figure 5). The patient could exercise for six minutes (4.4 METs). The Peak heart rate was 139/minute. Peak blood pressure was 150/90 mmHg. There were no symptoms. ST-segment deviations persisted during exercise (Figure 4 - Exer.) and recovery (Figure 5- Rec.). Electrocardiogram recorded from another ECG machine (Figure 6) did not show any abnormality. Findings of this patient further confirmed our feeling that ST-segment deviations recorded during the treadmill test were due to a fault in the styli of the printer of the treadmill system.

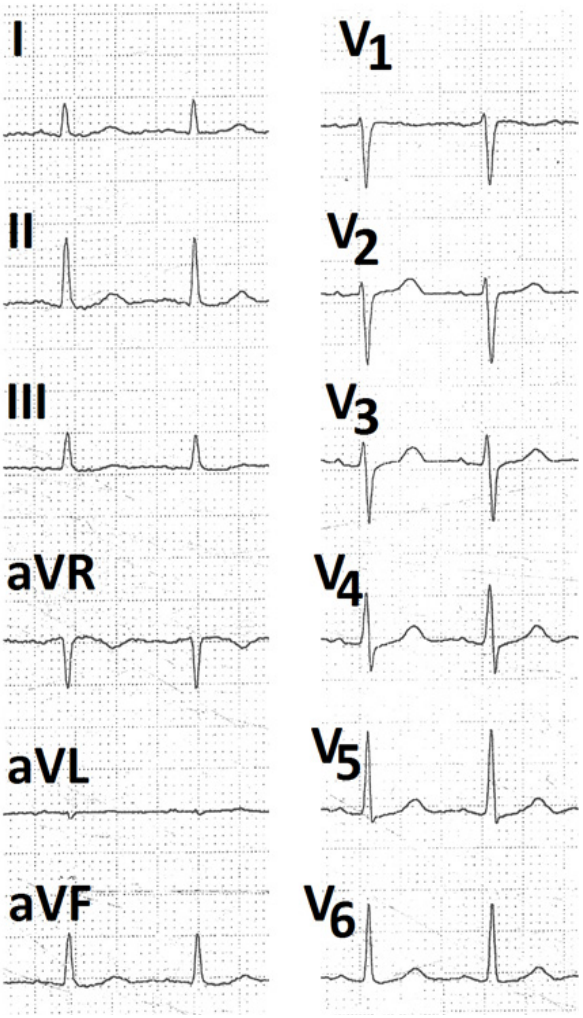

Figure 3: Electrocardiogram recorded from another ECG machine showing no ST-segment deviation.

Case -3

A treadmill test was performed on a 33-years-old female. She was a known diabetic but had no cardiac symptoms. Cardiac examination was normal. Echocardiographic examination was normal. The resting pulse rate was 73 beats per minute. Resting supine blood pressure was 120/80 mm Hg. Resting supine electrocardiogram recorded from the treadmill system (Figure 7-Rest.) showed slow upsloping. ST-segment depression in leads II, III, aVF, V5 and V6 (marked). Leads aVR, V1 and V2 showed ST-segment elevation (marked). Averaged beats printed simultaneously from different styli (Fig.8) did not show these abnormalities. The patient could exercise for 6:18 minutes (7.4 METs). The Peak heart rate was 158 beats/minute. Peak blood pressure was 150/80 mmHg. There were no symptoms or new electrocardiographic changes during exercise and up to six minutes of recovery. A review of raw electrocardiograms recorded during exercise (Figure 7 -Exer.) and recovery (Figure 8 Rec.) showed the same changes as in resting supine ECG (marked and). We recorded an electrocardiogram from another ECG machine. It did not show any ST-segment deviations (Figure 9).

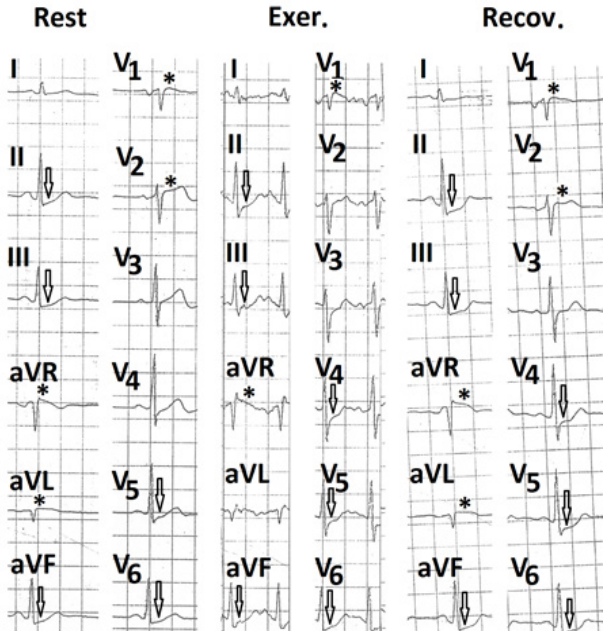

Figure 4: Raw electrocardiogram recorded during treadmill test showing slow upsloping ST-segment depression in leads II, III, aVF, V5 and V6 (marked) and ST-segment elevation in leads aVR, V1 and V2 (marked) at rest, during exercise (Exer.) and during recovery.

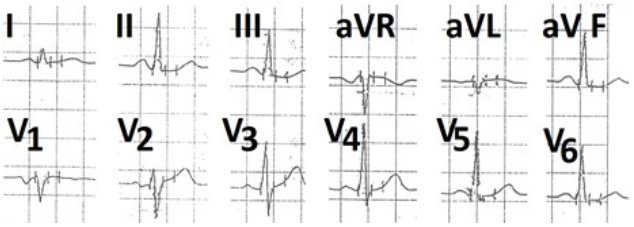

Figure 5: Averaged beats, at rest, printed from different styli, showing normal ST- segments.

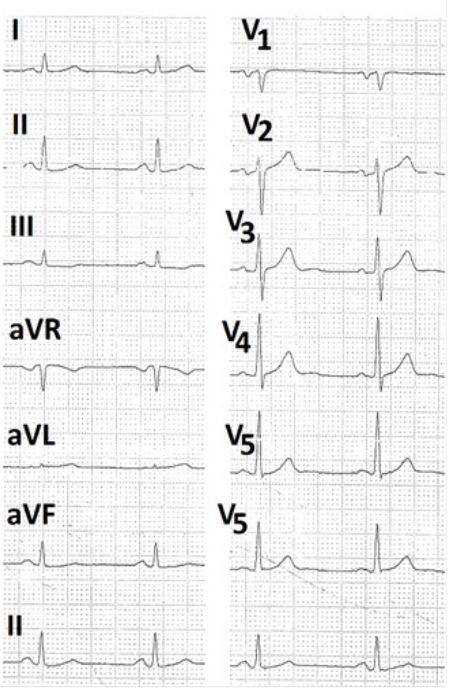

Figure 6: Electrocardiogram recorded from another ECG machine showing normal ST- segments.

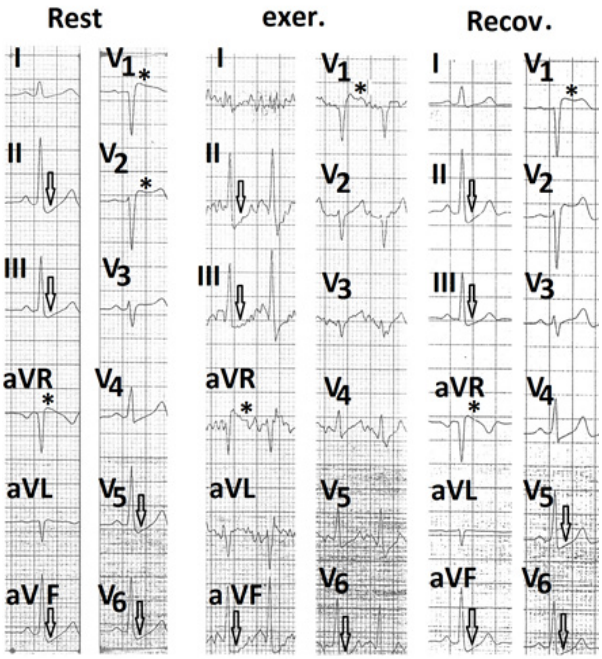

Figure 7: Raw electrocardiograms recorded during treadmill test showing slow upsloping ST-segment depression in leads II, III, aVF, V5 and V6 (marked) and ST-segment elevation in leads aVR, V1 and V2 (marked) at rest, during exercise and during recovery.

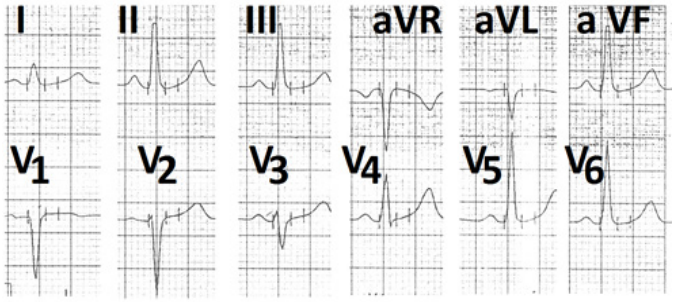

Figure 8: Averaged beats, at rest, printed from different styli, showing normal ST- segment

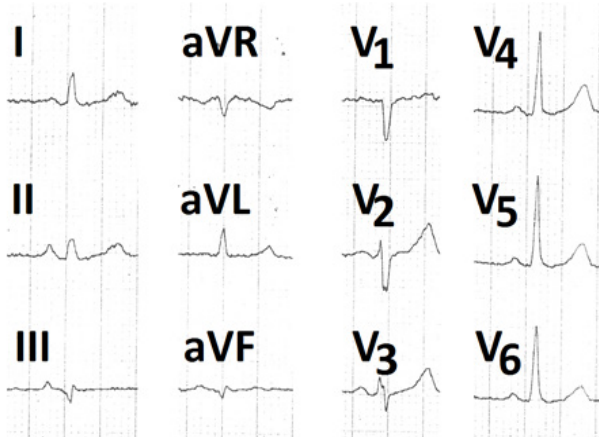

Figure 9: Electrocardiogram recorded from another ECG machine showing normal ST- segment.

Case -4

A 32-year-old male came for a treadmill test. He had no cardiac symptoms. There were no conventional cardiovascular risk factors. Cardiac examination was normal. Echocardiographic examination was normal. The resting pulse rate was 81 beats/minute. Resting supine

blood pressure was 130/90 mmHg. Resting supine electrocardiogram recorded from the treadmill system revealed upsloping ST-segment depression in leads II, III, aVF, V5 and V6. (Figure 10 -Rest marked). Leads aVR, aVL, V1 and V2 showed ST-segment elevation (marked) Once again, averaged beats, printed simultaneously from different styli did not show these changes (Figure 11). The patient could exercise for 10 minutes (11.3 METs). Peak heart rate was 162 beats/minute. Peak blood pressure was 170/90 mmHg. The patient had no symptoms or new electrocardiographic changes during exercise and up to six minutes of recovery. ST-segment changes persisted during exercise and recovery (Figure 10 - Exer. and Rec.)

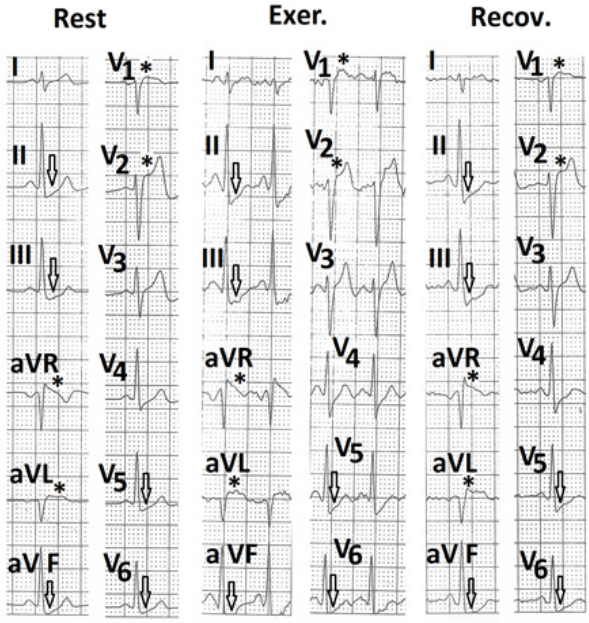

Figure 10: Raw electrocardiograms recorded during treadmill test showing slow upsloping ST-segment depression in leads II, III, aVF, V5 and V6 (marked) and ST-segment elevation in leads aVR, aVL, V1 and V2 (marked) at rest, during exercise (Exer.) and recovery.

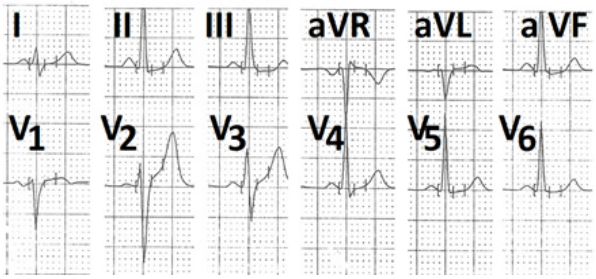

Figure 11: Averaged beats, at rest, printed from different styli, showing normal ST segments.

Discussion

All four cases showed upsloping ST-segment depression in leads II, III, aVF, V5, V6 and ST-segment elevation in leads aVR, aVL, V1 and V2 during exercise and recovery. This gave an impression of significant exercise-induced myocardial ischemia. However, there were several points against the possibility of myocardial ischemia. Firstly, all cases had a very low pre-test probability of coronary artery disease in view of the absence of symptoms, absence of conventional cardiovascular risk factors, negative family history, normal cardiovascular system examination and normal echocardiography [12]. Secondly, a supine electrocardiogram recorded before exercise also showed these changes. Thirdly, these changes were not present in the averaged beats printed simultaneously from different styli. Fourthly, none of the patients developed angina or angina equivalent symptoms during exercise or recovery. Fifthly, none of the patients developed any new diagnostic electrocardiographic findings during exercise or recovery. Finally, a resting electrocardiogram recorded from another ECG machine did not show these ST-segment changes.

In view of all these findings, we felt that the ST-segment deviations observed during the treadmill testing were probably due to over-damping of styli of the printer of a particular treadmill system. When a stylus presses more firmly than desired, on the electrocardiograph paper, it is called over-damping [13]. Over-damping hampers free movement of the stylus. Over-damping results in increased friction between the stylus and electrocardiograph paper. After inscribing the J point, the stylus takes a long time to return to baseline. This results in pseudo depression/elevation of the ST segment. Over-damping of stylus deviates ST segment in the direction of deflection of the terminal part of the QRS complex. When the terminal part is a down stroke (Figure 12a), the ST segment becomes depressed. This happened in leads II, III, aVF, V5 and V6 which had a prominent R wave. In these leads, the terminal part of the QRS complex was a down stroke. ST-segment, therefore, became depressed. In leads which show a QS or QR configuration, the terminal part of QRS is an upstroke. This happened in leads aVR, V1 and at times in lead aVL. ST-segment, therefore, become elevated in these leads (Figure 12b). Failure to appreciate this possibility can result in the wrong diagnosis of exercise-induced myocardial ischemia.

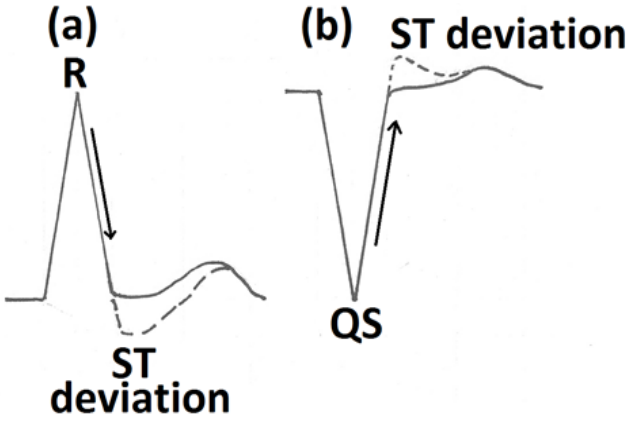

Figure 12: Diagram showing the genesis of ST-segment deviation (marked ----) in the direction of terminal deflection of QRS (marked arrow):

a: In leads showing R wave.

b: In leads showing Qr or QS wave.

Now a days, increasing number of asymptomatic persons come for periodic check-up including treadmill testing as a part of insurance, or requirement by their employee. Increasing health consciousness also drives a large number of asymptomatic patients for periodic health check-up. Treadmill stress electrocardiography is also a compulsory part of 'whole body check-up' performed by all corporate hospitals. Person with anxiety due to 'heart attack' or 'sudden death' in relative, friend or neighbourer also want to exclude 'sub-clinical coronary artery disease [14]. Exercise electrocardiography is also justified in asymptomatic athletes and persons engaged in occupation in which impairment might affect public safety e.g. airline pilots [15]. Test is also justified in fire fighters and law enforcement officers as these persons are susceptible to sudden death [15]. Significant coronary obstruction can be ruled out with considerable reliability if exercise electrocardiography is absolutely normal in a low risk patient. Exercise electrocardiography is also justified in persons with atypical discomfort with normal electrocardiogram [13]. Firstly, some patients may not be able to give proper history. Secondly, the symptoms may not be classical in all patients with coronary artery disease [16].

Other condition that can produce a false positive response during exercise electrocardiography include digitalis, left ventricular

hypertrophy, left bundle branch block, resting ST segment depression or prominent atrial repolarization waves. However, these conditions produce diagnostic changes not only in the supine electrocardiogram but also in averaged beats and ECG recorded from another machine. We observed that damping problem with the styli produces abnormalities only in raw ECG and not in the averaged beats and the ECG recorded from another machine. In these respects, the false positive response produced by the damping problem of styli differs from conventional false positive responses. Our observation is important because this cause of false positive response and its differentiating features are not mentioned in literature17-20 and a wrong interpretation of raw ECG may create undue anxiety and resultant unnecessary investigations & wrong treatment.

Coronary angiography was not ethically justified in these cases because we could make out that the changes in raw ECGs were mechanical artefacts and the patients had very low probability of significant coronary artery disease.

Conclusion

Over-damping of styli of the printer of a treadmill stress test system can produce ST-segment deviation in the direction of the terminal deflection of the QRS complex. This can give a false impression of exercise-induced myocardial ischemia. The presence of similar changes in the resting electrocardiogram and the absence of ST-segment abnormalities in the average beats and the electrocardiogram recorded from another ECG machine can give the correct diagnosis.

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