Electrocardiographic Responses to Maximal Exercise during Acute Pericarditis and Early Repolarization*

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Exercise testing is contraindicated during active pericarditis because of the possibility of myocarditis. In a patient suspected of having ischemic heart disease, a pericardial rub appeared for the first time following a maximal exercise test, during which the elevated J-points descended to baseline. In two normal volunteer subjects with early repolarization during a maximal exercise test, the elevated J-points behaved similarly. We conclude that, contrary to previous belief, electrocardiographic exercise responses cannot distinguish between pericarditis and early repolarization.

There is no clinical reason for exercise testing of patients with acute pericarditis, particularly those with ST-T changes. ST (J-point) elevation occurs due to variable degrees of subjacent myocarditis. Patients who exercise after a diagnosis of myocarditis, with or without pericarditis, do poorly compared to those who do not. Moreover, in experimental myocarditis, exercise augments intramyocardial virus replication with greater cardiac hypertrophy, more extensive inflammation, and more necrosis and death than in nonexercised control subjects. Thus, during pericarditis, the possibility of myocardial involvement makes exercise unwarranted. In a patient suspected of having ischemic heart disease, the true diagnosis, acute pericarditis, was unsuspected until immediately after maximal treadmill exercise, affording an unusual opportunity to document the ECG response. We also compared exercise responses in subjects with generalized ST elevation of early repolarization, a normal ECG variant resembling the quasi-diagnostic (stage I) changes of acute pericarditis. ST (J) elevations in early repolarization are said to disappear with exercise, a feature distinguishing it from pericarditis. In our pericarditis patient, elevated STs descended during exercise, questioning the specificity of that response. We also exercised two volunteer subjects without heart disease who had early repolarization.

**Case Report**

A 56-year-old man with chest pain was admitted to the coronary care unit for possible myocardial infarction. Forty-eight hours from onset, ST became elevated in leads 2, 3, aVF and V₃, remaining isoelectric elsewhere. Although such a ST distribution is not rare in acute pericarditis, restricted lead distribution is more characteristic of acute infarction, which was therefore suspected. Yet no enzyme elevations or evolutionary T-wave changes followed, and the patient

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**Figure 1A.** Pericarditis: beginning of treadmill exercise test (Bruce protocol). Top to bottom: ECG leads aVF, V₂, V₃. Left: Standing rest—ST (J) elevations in all traces. Left center: No significant change with hyperventilation. Right center: ST (J) has descended to the ECG baseline (TP interval); PR segments depressed. Right: ST (J) remains at baseline at 4 minutes of exercise while PR segment depression is exaggerated.
had an uneventful course. Before discharge he was exercised on the treadmill (Bruce protocol; continuous leads aVF, V1, V6) without symptoms. Routine auscultation to detect any murmur, S1 or S2, then disclosed only a three-phase pericardial rub. The whole clinical picture appeared consistent with acute idiopathic pericarditis. Figures 1A and B show ECG responses before and during exercise, peak exercise and two and four minutes postexercise. ST elevation is seen in standing controls in all leads, including hyperventilation. At one minute of exercise, ST has descended to baseline (T-P interval) and PR segments begin to be depressed. At four minutes, ST remains isoelectric with increased PR segment depression. After 15 minutes, maximal exercise STs are isoelectric or slightly depressed with PR segments clearly depressed. Postexercise, there is considerable normalization at two minutes, at four minutes, J-points are isoelectric with slight PR segment depression.

Early Repolarization

Two normal volunteer subjects with early repolarization exercised 10 and 11 minutes respectively to reach age-determined maximum heart rate. Identical results are summarized for one subject in Figure 2. ST in aVF, V1, and V6 are almost indistinguishable from those of the pericarditis patient. As exercise progresses (especially at peak), there is ST depression with some PR segment depression. Except for less PR segment depression, results with early repolarization closely resembled those with pericarditis.

Discussion

This partly serendipitous investigation suggests that: 1) standardized maximal exercise testing cannot reliably distinguish early repolarization from the state T-ECG of acute pericarditis; and 2) exercise in the pericarditis patient did not increase the ECG counterpart of subepicardial myocarditis (elevated ST), but rather exaggerated the atrial repolarization abnormality responsible for PR segment depression, as previously reported in detail for the resting ECG. Previous reports agree that exercise usually nullifies the ST elevations of early repolarization. The traditional belief that exercise does not do this in acute pericarditis (distinguishing it from early repolarization) appears to stem from a report of a patient who had low level exercise and ECG tracings only after some post-exercise interval. Our patient underwent physiologically "maximal" exercise. Exercise-induced PR segment depressions are also nonspecific be-

Figure 1B. Pericarditis: completion of exercise test. Top to bottom: Leads aVF, V6, V1 from maximum exercise to 4 minutes post exercise. Left: Peak exercise at 15 minutes; ST (J) is slightly depressed although the TP baseline is almost eliminated by rapid rate. PR segment depression remains. Center: ST (J) slightly depressed; PR segments less depressed. Right: 4 minutes post exercise; ST (J) on baseline level PR segments slightly depressed.

Figure 2. Early repolarization: treatmmill exercise (lead V1). Top: standing ST (J) elevation. Center: four minutes exercise; ST (J) has descended to baseline and PR segment is slightly depressed. Bottom: peak exercise, 11 minutes: ST (J) and PR segment depressed beneath T-P baseline.
the absence of ST changes.\textsuperscript{14} They represent early appearance of the atrial repolarization (Ta) wave.\textsuperscript{15} Normally, Ta occurs invisibly during the QRS, but appears earlier in many pericarditis patients producing PR segment deviation. All our subjects did not have PR deviations before testing, so that exercise appeared to bring out latent PR segment deviation with and without pericarditis. Return of elevated STs to the baseline is harder to explain in view of the intensifying effects of exercise on acute myocarditis,\textsuperscript{4} the cause (though presumably subepicardial\textsuperscript{15}) of ECG changes in acute pericarditis. Since we would not intentionally exercise patients with acute pericarditis, no series to quantitate this (vs early repolarization) can be designed.

Therefore, acute pericarditis appears to contraindicate exercise challenge, so that responses we report strictly apply to our patient. Yet, they question the proposal that exercise would not change or exacerbate the ST abnormalities of acute pericarditis. Taken with the results in early repolarization, this serendipitous finding reduces or eliminates the reported utility of the exercise ECG in differentiating the two conditions.

REFERENCES
4 Chapman DW, Overholt L. Acute benign idopathic pericarditis; a report of 20 cases. Arch Intern Med 1957; 99:708-15
5 Spodick DH. The electrocardiogram in acute pericarditis: distributions of morphologic and axial changes by stages. Am J Cardiol 1974; 33:470-74
7 Kino M, Shahamatpour A, Spodick DH. Auscultatory perception of the fourth heart sound: the effects of S4-S1 interval and aging. Am J Cardiol 1976; 37:849-52
8 Spodick DH. The pericardial rub: a prospective, multiple observer investigation of pericardial friction in 100 patients. Am J Cardiol 1975; 33:357-62

Posterior Mediastinal Sarcoidosis*


We report two cases of enlargement of the posterior mediastinal lymph nodes due to sarcoidosis. Bilateral hilar enlargement, pulmonary parenchymal involvement, or extrathoracic manifestations of sarcoidosis were absent. A diagnostic thoracotomy had to be performed in both instances.

Sarcoidosis is a systemic disease of unknown origin characterized by the presence of noncaseating granulomas in one or more organs.\textsuperscript{1} Although intrathoracic lymph nodes are often involved, posterior mediastinal lymph nodes are only rarely affected. To our knowledge, no reports of sarcoidosis of the posterior mediastinal lymph nodes without extramediastinal manifestations of disease have previously been documented in the world literature.

CASE REPORTS

CASE 1

A 45-year-old white woman was admitted on May 3, 1982 for investigation of high-grade fever, cough, and shortness of breath at rest. A chest x-ray film demonstrated streaky infiltrates of both the right and the left pulmonary bases. In addition, there was a moderate superior mediastinal widening, without bilateral hilar enlargement. Computerized tomography confirmed the presence of an enlarged right paratracheal lymph gland projecting behind the superior vena cava.

Transbronchial lung biopsies (n = 5) were performed and were free of pathologic changes. Analysis of blood showed a mild hypercalcemia (10.7 mg/dl). Cutaneous testing for Mycobacterium tuberculosis and Dermatophagoides pteronyssinus were positive. No mycobacteria were isolated from sputum, urine, or gastric contents. There were no precipitating antibodies against a wide variety of fungi, including the following: Aspergillus fumigatus; Aspergillus niger; Candida albicans; Microsporid spurae; Penicillium notatum; Penicillium brevi compactum; and Thermophylospora polyspora. Serologic screening revealed a fourfold increase in titer of complement fixation antibodies for Mycoplasma during hospitalization. Consequently, the diagnosis of Mycoplasma-induced pneumonia was made.

After treatment the patient was lost to follow-up during the next two years. On Nov 11, 1984, she came to our outpatient clinic with a history of nonproductive cough. Physical examination revealed no abnormal findings. In particular, there were neither enlarged peripheral lymph nodes nor hepatosplenomegaly. A control chest x-ray film showed an increased widening of the superior mediastinum. Hilar enlargement and the streaky infiltrates, present on the previous chest x-ray film, were absent. Computerized tomography demonstrated a round mass located in the posterior mediastinum (Fig 1A).

On right thoracotomy a firm glandular mass 7.5 by 6 cm was found between the axillary vein and the esophagus. The mass was removed, and histologic examination showed the presence of noncaseating epithelioid granulomas, documenting the diagnosis of sarcoidosis (Fig 1B). Signs of fungal infection were absent. A Ziehl-Neelsen

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