We present a case of hypovolemic shock accompanied by electrocardiographic changes classically associated with acute myocardial infarction. Prompt therapeutic intervention, which included correction of the hypovolemic shock, resulted in stabilization of the patient's clinical course. Increased activities of the cardiac-specific enzymes in serum were not documented. Serial electrophoretic determinations of the isoenzymes of serum lactate dehydrogenase did not show the characteristic changes associated with myocardial infarction. Accurate determination of the serum isoenzymes provided valuable diagnostic information which, accompanied by the patient's clinical improvement, mitigated strongly against the occurrence of myocardial infarction.

Acute myocardial infarction is a straightforward diagnosis in the patient who presents with typical substernal chest pain; electrocardiographic abnormalities that include the sudden development of abnormal Q waves, or ischemic ST segment and T-wave changes; and increased serum activity of the cardiac-specific enzymes. Indeed, some may make the diagnosis if any two of these three abnormalities are confirmed (1). Occasionally, however, conflicting data preclude accurate diagnosis until the complete clinical picture has evolved. Here we present a case that illustrates these difficulties.

Case History

The patient, a 66-year-old man, was admitted to the NIH Clinical Center for evaluation and treatment of lymphomatoid granulomatosis. Past medical history revealed that he had been a heavy cigarette smoker for 40 years. A few years before this admission he had been noted to have an irregular cardiac rhythm and was subsequently treated with procainamide for ventricular premature contractions. No other history of serious illness was elicited.

Physical examination revealed fever, abdominal tenderness, and hepatosplenomegaly. Results of examination of the heart were normal. Laboratory evaluation demonstrated anemia, increased erythrocyte sedimentation rate, and a normal leukocyte count. No source of infection, to explain the fever, was found. The values for routine clinical chemical determinations were all within the expected ranges. The electrocardiogram was normal except for low voltage amplitude in the limb leads.

Treatment with cyclophosphamide and prednisone was begun, and at first the patient showed clinical improvement. However, after the 60th hospital day he became increasingly short of breath and developed edematous swelling of the feet and legs. Supplemental oxygen improved his respiratory status. That the deep veins of the left leg were obstructed was demonstrated by venography. A presumptive diagnosis of deep-vein thrombosis with pulmonary embolism was made and anticoagulation therapy was instituted with heparin and warfarin. On the 72nd hospital day the electrocardiogram (Figure 1A) was unchanged from admission.

On the 79th hospital day the hematocrit and hemoglobin showed persistent anemia. The leukocyte count had dropped to 2200/μL. Alkaline phosphatase (EC 3.1.3.1) activity was increased and lactate dehydrogenase (EC 1.1.1.27) activity was 494 U/L (expected normal 115–340 U/L), while the bilirubin, alanine aminotransferase (EC 2.6.1.2), and aspartate aminotransferase (EC 2.6.1.1) values remained within the expected range.

At this time, extensive pulmonary involvement with soft-tissue masses was demonstrated by chest roentgenography and computerized axial tomography. Because of the rapidly advancing primary disease process, we began more aggressive therapy, in the form of radiation and antibiotics. Because of severe hypotension, with values for systolic blood pressure in the range of 8.0 to 9.3 kPa (60 to 70 mmHg), and respiratory impairment on the 91st hospital day, the patient was intubated and mechanically ventilated. An electrocardiogram at this time revealed pathological Q waves in precordial leads V₁–V₅ (Figure 1B). A ventilation-perfusion scan was not suggestive of pulmonary embolism. Total serum lactate dehydrogenase and creatine kinase activities are given in Table 1. On the 92nd hospital day an electrocardiogram (Figure 1C) showed even deeper Q waves across all of the precordial leads and ST segment elevation in precordial leads V₂–V₆. These findings were believed to be consistent with extension of an anterior septal myocardial infarction. Hemodynamic measurements were monitored with an indwelling double lumen pulmonary arterial catheter. Initial pulmonary-artery balloon-occlusion pressure was 1.2 kPa (9 mmHg; normal, 0.67–1.33 kPa, or 5–10 mmHg). This increased to 2 kPa (15 mmHg) with an intravenous fluid challenge and was accompanied by a concomitant normalization of the arterial blood pressure (brining systolic pressures to the range of 16 to 18.6 kPa, or 120–140 mmHg) and improvement in the urine output.

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Adequate blood pressure was maintained by administering intravenous fluid and the patient remained stable for the next 10 days. An electrocardiogram on the 99th hospital day demonstrated the return of normal QRS complexes in the anterior precordial leads (Figure 1D). Nonspecific ST-segment and T-wave changes, however, persisted. The patient continued to require mechanical ventilation to adequately support respiration. He was unresponsive to verbal stimuli and was noted to be severely thrombocytopenic. Despite supportive efforts, another severe hypotensive episode resulted in death on the 109th hospital day.

An autopsy was not performed.

Discussion

In this patient the development of hypotension in the presence of electrocardiographic changes consistent with global infarction was suggestive of cardiogenic shock. However, the documentation of an initially low pulmonary-artery occlusion pressure, the favorable response of the blood pressure to fluid challenge, and the subsequent survival of the patient for several weeks combined to make this possibility unlikely. More importantly, serum enzyme and isoenzyme determinations failed to confirm the presumptive diagnosis of myocardial infarction. The values for the serially measured activities (Table 1) of total lactate dehydrogenase and total creatine kinase in the serum show no sharp increases such as would be expected in a case of massive myocardial infarction complicated by cardiogenic shock. The lactate dehydrogenase activity remained increased above the reference range, but no convincing temporal relationship to electrocardiographic changes was observed. Total creatine kinase activity remained within the reference range. The isoenzymes of creatine kinase (especially CK-M), which may have provided more clinically useful information, unfortunately were not measured.

The lactate dehydrogenase isoenzymes discussed here were quantitated by an electrophoretic method (2). Figure 2 shows the results of the serial determination. Increased activity of isoenzymes LD1 and LD2, such as is known to occur after acute myocardial infarction (3, 4), was not observed in this case. A more important discriminant of myocardial infarction is the ratio of LD1/LD2 (5-7). In normal human serum the ratio of LD1/LD2 is <1, averaging about 0.75. After myocardial infarction, a characteristic reversal occurs, the ratio of LD1/LD2 becoming transiently >1 between 18 and 72 h after myocardial infarction, with the ratio being highest at about 48 h. Figure 3 shows the serum lactate dehydrogenase isoenzyme patterns obtained in a patient with documented myocardial infarction. Our patient demonstrated no reversal of the LD1/LD2 ratio. The persistent above-normal values for total serum lactate dehydrogenase activity may be a result of the patient's primary disease with pulmonary involvement complicated by hypotension.

Although abnormal Q waves usually indicate myocardial necrosis, the loss of initial electrical forces thus represented may be seen in other clinical conditions, such as the actual loss of viable myocardium, as may occur with primary myocardial disease and with infiltrative cardiomyopathies. They may also result from an increase in electrical forces contralateral to the recording electrode, associated with hypertrophy of the ventricular myocardium, as may occur with idiopathic hypertrophic subaortic stenosis or with left ventricular hypertrophy accompanying hypertension or aortic stenosis. In the absence

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<th>Hospital Day</th>
<th>LD(U/L)</th>
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<tr>
<td>91</td>
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Reference Range: 115-340, 50-200
of myocardial infarction, Q waves may occur transiently with clinical events such as cerebral hemorrhage (8), uremia (9), pancreatitis (10), pulmonary embolism (11, 12), or myocardial ischemia without frank necrosis (13). Alternatively, Q waves subsequent to actual infarction may disappear as soon as five to 10 days later (14). As the adjacent ischemic myocardium recovers, sufficient initial electrical forces are generated to mask Q waves originating from the necrotic zone.

The most likely source of the Q waves in this patient was profound transient ischemia, perhaps occasioned by hypotension in the setting of pre-existing coronary artery disease. Pulmonary embolism is an unlikely cause, because of the anterolateral location of the Q waves. This is consistent with the ventilation-perfusion scan, which did not suggest pulmonary embolism. Although the Q waves of myocardial infarction may be transient, the electrocardiographic changes in this patient suggested extensive necrosis of the left ventricle. It is unlikely that recovery of bordering ischemic tissue would be sufficient to mask the Q waves originating from such an extensive zone of infarction. Artifactual sources of pseudo-Q waves, such as malposition of chest electrodes, were excluded by consistent changes noted on several electrocardiograms and by physician supervision of electrode placement.

Loss of electrical activity sufficient to cause Q waves has generally been associated with myocardial necrosis; however, severe metabolic alteration may occur without irreversible tissue damage (15). Transient patterns of myocardial infarction have been produced in experimental animals by intravenous infusion of norepinephrine (15) and by experimental coronary artery occlusion (16). Although histological examination showed decreased myocardial glycogen and impairment of succinate dehydrogenase (EC 1.3.99.1) activity (15), myocardial infarction did not occur. Similarly, there is good clinical documentation of transient abnormal Q waves in association with coronary insufficiency. Haiat and Chiche (13) noted transient abnormal Q waves in 15 patients, in eight of whom myocardial ischemia was present without infarction.

As seen from this case, the clinical differentiation of transient abnormal Q waves with true infarction from those ascribable to ischemia or other causes may be extraordinarily difficult. Isoenzyme determinations that allow one noninvasively to determine the presence of myocardial necrosis are of key importance in making such distinctions. This is illustrated by the electrophoretic technique used here, which is sensitive and accurate enough to detect peri-operative myocardial infarction in patients who have undergone cardiac surgery (5). The data obtained from serial electrocardiograms, isoenzyme determinations, and the clinical course of the patient must then be interpreted together to arrive at the appropriate diagnosis.

References