Cell-mediated immunity to myoglobin in polymyositis

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SUMMARY Using the leucocyte migration inhibition (LIF) test we looked for evidence of cell-mediated hypersensitivity against myoglobin in 8 patients with polymyositis (PM) or dermatomyositis (DM). The migration index for PM-DM patients was 47·5 ± 17%, while in the controls the index was 86 ± 12% (p<0·001). The presence of serum antibodies against myoglobin was also investigated by passive haemagglutination (PH) and counterimmunoelectrophoresis (CIE). By PH the reciprocal titre of antimyoglobin antibodies was 150 ± 28 in PM-DM compared with 16·2 ± 15·9 and 8·7 ± 7·7 in control patients with diseases (p<0·01) and negative in normal persons. CIE showed antimyoglobin antibodies in 3 PM-DM patients and in none of controls. Cell-mediated immunity against myoglobin may be implicated in the pathogenesis of PM. The pathological significance of antimyoglobin antibodies remains to be determined.

Polymyositis (PM) is an inflammatory muscle disease that affects mainly proximal muscular groups; when the skin is affected it is called dermatomyositis (DM). The aetiology is unknown and the pathogenesis obscure; however, some immunological features have been described. These include direct mononuclear cytotoxicity to muscle fibres and lymphokine-mediated cytotoxicity to fetal muscle when PM-DM mononuclear cells have been previously cultured with autologous muscle extract. Furthermore, when patients' mononuclear cells are stimulated in culture with muscle tissue they undergo blastogenesis.

Several autoantibodies have been found in PM-DM patients, including anti-PM-1, the Jo-1 antibody system, antimyosin, and antimuscle antibodies. In addition deposits of immunoglobulins and complement have been reported in the vessel walls of involved muscles. By passive haemagglutination Nishikai and Homma found antimyoglobin antibodies in patients with PM-DM, while in control groups and in patients with other myopathies such antibodies were either absent or in very low titre. To our knowledge no specific muscle antigen has been implicated in cell-mediated hypersensitivity to muscle in PM-DM patients. Myoglobin is a major component of striated muscle and is not found in smooth muscle. We therefore sought evidence of delayed hypersensitivity and specific antibodies directed against myoglobin in patients with PM-DM.

Materials and methods

Patients. Eight patients with PM-DM according to the criteria proposed by Bohan and Peter were studied. Three had polymyositis, 4 typical dermatomyositis, and one childhood dermatomyositis. None had either associated neoplasia or overlap syndrome. Two patients were considered active, as defined by high serum enzyme levels, muscle tenderness, mild fever in the absence of infection, and high sedimentation rate (Wintrobe). Other conditions producing high serum enzyme levels were ruled out. Seven patients were receiving prednisone (5 to 60 mg per day); 2 were also receiving azathioprine (100 and 150 mg daily), and one patient was untreated at the time of the study. The normal control group comprised 8 healthy individuals. Control disease groups were 8 patients with systemic lupus erythematosus (SLE) who had 4 or more ARA criteria and 8 with classic or definite rheumatoid arthritis (RA) according to the ARA criteria. These disease groups were included only in the serological studies.

Preparation of patients' cells. Peripheral blood was obtained by venepuncture with heparinised syringes and left to sediment spontaneously for 90 minutes. The
leucocytes in the supernatant plasma were washed thrice in Hank's balanced salt solution (HBSS). After the last washing, the cells were resuspended in 199 medium (Difco, Detroit, Michigan) and adjusted to a concentration of 20 × 10⁴ per ml. Viability always exceeded 95% by trypan blue exclusion.

Myoglobin isolation and purification. Myoglobin was isolated by a modification of Singer's method. Human muscle fragments were obtained within 2 hours of death and stored at −70°C. The fragments were minced and homogenised, and, except where noted, the pH was maintained at 7-0 during the procedure. The unpigmented proteins were precipitated with 0·5 M basic acetate. The supernatant was treated with phosphate mixture (Na₂HPO₄ 160 mg, Na₂HPO₄ 40 mg, for each 20 g of muscle), and dialysed against ammonium sulphate solution in progressive concentrations from 40 to 100% for 8 to 24 hours. After the last dialysis the metamyoglobin was precipitated at the bottom of the dialysis bag. To remove the sulphate from the myoglobin a further 24-hour dialysis against phosphate buffered saline (PBS) pH 7-4, 0-01 M was performed. The myoglobin extract was purified by Sephadex G-50 gel filtration (Pharmacia Fine Chemicals, Uppsala, Sweden) in a 2·6 × 60 column (Pharmacia) at an elution speed of 60 ml per hour, and 3 ml samples were collected in glass tubes with an LKB-8300 Uvikord II fraction collector. Myoglobin purity was assessed by cellulose acetate gel electrophoresis in a Beckman 110 densitometer. Further characterisation of myoglobin was in a Carl-Zeiss PMQ-II spectrophotometer. Protein concentration was determined by Lowry's method. The myoglobin sample was sterilised by Millipore filtration with 22 µm pore size (Millipore Corp., Bedford, MA).

Leucocyte migration inhibition (LIF) test. The LIF test was done according to modified Bendixen and Søborg's method. Briefly, Mackaness type migration chambers (Falcon Plastics, Oxnard, CA) were filled with either 199 medium alone or 199 medium containing 1% myoglobin. The cells were taken up in capillary tubes (Propper Manufacturing Co. Inc., Long Island City, NY) and centrifuged at 200 g for 15 min. Portions of the capillaries containing the cell pellets were placed in the chambers. Experiments were done either with PM-DM cells or with healthy donor cells. The chambers were incubated for 48 hours at 37°C. Each assay was done in quadruplicate, and results were included only when reproduced at least 3 times. The migration areas were measured by projection on paper, the shaded areas being cut out and weighed in a precision balance. The migration index was defined as:

\[
\text{Migration} = \frac{\text{mean area of migration of cells plus antigen}}{\text{mean area of migration of cells alone}} \times 100.
\]

Absorption of sera. Sera were heat-inactivated at 56°C for 30 min and then in order to remove heterophile antibodies were absorbed for one hour with sheep red blood cells (SRBC) at room temperature.

Passive haemagglutination (PH). SRBC were coated with human myoglobin by the technique described by Nishikai and Homma. Myoglobin-coated tanned SRBC (My-SRBC) were resuspended at 5% in HBSS. The PH assays were done in Microtiter U-plate multwell (Cooke Engineering, Alexandria, VA) containing 0·2 ml of 0·5% heat-inactivated rabbit serum in HBSS, 0·2 ml of either patient or control serum in dilutions from 1:10 to 1:160, and 0·2 ml of My-SRBC suspension. The U-plates were first incubated for 60 min at 37°C and then overnight. After 18 hours' incubation the haemagglutination in each microwell was recorded.

Counterimmunoelectrophoresis (CIE). This was done in a Hyland unit (Hyland, Costa Mesa, CA) by the method of Gocke and Howe. Plastic 10 × 10 plates with 2% agarose (Sigma Chemical Co., St Louis, MO) prepared in barbital buffer 0·05 M, pH 7·2 were used. The running time was 45 minutes at 30 mA. The myoglobin was placed in the cathode well at a concentration of 5·5 mg/ml.

Statistical analysis was by Student's t test.

Results

Antigen

After Sephadex G-50 gel filtration of human myoglobin (Fig. 1) the cellulose acetate gel electrophoresis showed that it was pure myoglobin with beta electrophoretic migration pattern. Spectrophotometric characterisation showed 2 peaks at 502 and 624 nm, confirming its nature (Fig. 2). The protein concentration in the sample was 5·5 mg/ml (5·5 g/l).

LIF test

When incubated with 199 medium alone the PM-DM leucocyte migration area was taken as 100% and did not differ from that of the control leucocytes incubated in the same way. When PM-DM cells were incubated in presence of myoglobin the migration index was 47·5 ± 17% (range 10–63%), significantly less than the control index when incubated with myoglobin, which was 86 ± 12% (p<0·001). Fig. 3 shows the individual migration indices.

Passive haemagglutination

All the PM-DM patients had antibodies to myoglobin, their mean reciprocal titre being 150 ± 28 (range 80 to 160). Values for the disease controls were 16·2 ± 15·9 for RA and 8·7 ± 7·7 for SLE, both differences being significant (p<0·01). Healthy control sera were all negative (Fig. 4).
Fig. 1 Sephadex G-50 gel filtration chromatography of human myoglobin. The elution speed was 60 ml per hour, myoglobin eluted from fractions 15 through 23 (3 ml fractions were collected). The graph was plotted in an LKB spectrophotometer fraction analyser.

Fig. 2 Spectrophotometric characterisation of human myoglobin in 0.01 M PBS, pH 7.4. The characterisation was done from 400 to 700 nm. The absorption spectrum (502 and 624 nm) is characteristic of myoglobin.

Fig. 3 LIF test to myoglobin. The differences between PM-DM patients (left side) who had a migration index from 10 to 63% are evident when compared with normal persons who had a range from 60 to 100% (see text).

In order to define the antmyoglobin specificity found by PH, absorption studies were done as follows: sera were incubated for 30 min at 37°C with 1% myoglobin solution in 0.01 M PBS. All sera tested in this way became negative for antmyoglobin activity by PH. A further attempt to define this specificity was by indirect immunofluorescence with mouse muscle as substrate. By this method all sera showed 2 staining patterns: both sarcolemmal and sarcoplasmatic. When sera were previously absorbed with MySRBC, the sarcoplasmatic staining disappeared and sarcolemmal remained positive (data not shown).

Counterimmunoelectrophoresis was positive in only 3 of the 8 patients, 2 of them with active disease. All the controls were negative.
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Fig. 4 My-SRBC passive haemagglutination by PM-DM sera. The highest titre tested was 1:160. By this method all patients had antimyoglobin antibodies at titres of 1:80 or more; 5 SLE and 6 RA patients had antimyoglobin antibodies at titres of 1:40 (2 patients) or below (see text).

Discussion

We have demonstrated cell-mediated hypersensitivity to myoglobin by the LIF test in patients with PM-DM and confirmed the presence of anti-myoglobin antibodies by PH. No previous study has reported cell-mediated immunity to a specific muscle antigen in PM-DM.

In PM-DM the cellular infiltrates in the inflamed muscles are mainly mononuclear, suggesting that a cell-mediated immune mechanism produces the tissue injury. Our findings are in accordance with this hypothesis. Several studies\(^1\)\(^-\)\(^4\) have found evidence of cell-mediated immunity against muscle in PM-DM, and our findings suggest that myoglobin is acting as antigen in this respect. Recently Haas\(^2\) failed to find antimuscle cytotoxicity with PM-DM mononuclear cells using xenogeneic target cells of rat origin. In our study the myoglobin was of human origin, so that in PM-DM the aberrant cellular immune response may be directed against antigenic determinants of myoglobin not shared by these 2 species, which does not seem to be the case for the humoral response, since antimyoglobin antibodies were absorbed with mouse muscle. Another possible explanation for these discrepancies may be the different systems tested.

LIF production is a feature of delayed hypersensitivity.\(^2\)\(^\text{a}\) Other mechanisms capable of producing migration inhibition seem unlikely to explain our results. Immune complexes\(^2\)\(^\text{a}\) inhibit cell-migration in a nonspecific way; in our experiments the cells were washed to remove plasma components. Nevertheless immune complexes may have been membrane-bound to the polymorphonuclear leucocytes, and we did not exclude this possibility. However, circulating immune complexes are not a recognised feature of PM-DM. Further, the cells migrated normally when incubated in the absence of myoglobin. Fibrin aggregates may also interfere with migration,\(^2\)\(^\text{a}\) but in the present study the blood was heparinised, and washing the cells removed clotting factors.

Antimyoglobin antibodies were detected by PH in all the patients with PM-DM and, at lower titres, in some of disease controls. The absorption studies confirmed its specificity. The method used is highly sensitive. CIE was positive in only 3 patients and in none of the controls. This method is less sensitive but highly specific for antimyoglobin antibodies.

What incites the immune response against myoglobin in PM is unknown. While we have shown that in PM-DM there is cell-mediated immunity against myoglobin, we do not know whether it occurs as a primary event and is responsible for the tissue damage, or whether it is secondary to muscle injury. Further studies are required to define the significance of these findings.

References

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