Humoral and cell mediated immune response to cow’s milk proteins in Behçet’s disease

G Triolo, A Accardo-Palumbo, F Dieli, F Ciccia, A Ferrante, E Giardina, G Licata

**Objective:** To investigate the humoral and cellular immune response against cow’s milk proteins in Behçet’s disease and to distinguish any behaviour during active or inactive disease.

**Methods:** Peripheral blood mononuclear cells from 16 patients and from eight normal controls were cultured in the presence of phytohaemagglutinin (PHA), β-casein, β-lactoglobulin, or chicken egg albumin. Interferon γ (IFNγ) and interleukin 4 (IL4) were measured in the culture supernatants by enzyme linked immunosorbent assay (ELISA). Serum samples from 46 patients with Behçet’s disease and from 37 healthy subjects were also studied for antibody detection. Antibodies to β-casein, β-lactoglobulin, and chicken egg albumin were determined by ELISA.

**Results:** High IFNγ but not IL4 levels were found in the supernatants of lymphocytes from patients with active disease cultured in the presence of cow’s milk proteins. Levels were comparable with those obtained in cultures stimulated with PHA. A significantly higher level of anti-β-casein and anti-β-lactoglobulin IgG and IgA antibodies was found in patients with active Behçet’s disease. No relation was found between their occurrence and the age of the patients, the duration of disease, or the presence of gastrointestinal abnormalities. Antibodies to chicken albumin were detected at low levels and with a prevalence similar to that of healthy subjects.

**Conclusion:** The results indicate that an active immune response occurs in Behçet’s disease. This response involves an increased frequency of antibodies to cow’s milk protein and a strong Th1 polarisation after exposure to these antigens. The occurrence of these abnormalities supports a putative role for cow’s milk proteins immune response in the pathogenesis of Behçet’s disease.

**PATIENTS AND METHODS**

**Participants**
We studied 46 patients (26 men, 20 women) with BD who fulfilled the diagnostic criteria of the International Study Group for Behçet’s disease. The mean (SD) duration of the disease was 12.5 (9.7) years (range 2–40); the patients’ ages ranged from 14 to 68 years (mean 40). Criteria for exclusion from the study were coexistent autoimmune disorders and gastrointestinal manifestation fulfilling the diagnosis of inflammatory bowel disease. Twenty eight patients had at least two of the major manifestations in the active stage at the time of blood withdrawal. Disease activity was assessed by the 1994 criteria of disease activity for BD, which were proposed by the BD Research Committee of Japan. Thirty seven healthy subjects of equivalent age, six patients with Crohn’s disease, and 16 adult patients with CD were included in the study.

**Preparation of human peripheral blood mononuclear cells and culture conditions**
Peripheral blood mononuclear cells (PBMC) were obtained by separating heparinised venous blood on Ficoll-Hypaque (Euroclone, UK), as previously described. Viable mononuclear cells which excluded trypan blue were counted with a haemocytometer (viability always >90%) and then diluted in RPMI medium to a concentration of 1x10⁶ cells/ml. All experiments were performed in multiwell tissue culture plates, and cultures were set up in quadruplicate. Cultures of PBMC were stimulated by the addition of phytohaemagglutinin (PHA, 10 µg/ml; Sigma) or treated with various doses of β-casein (βC) or β-lactoglobulin (βLG); or chicken egg albumin (OA); (1, 10, 100 µg; final concentration; Sigma). Cultures were incubated for 72 hours in 5% CO₂ at 37°C. After incubation, viability was assessed again and supernatants stored for cytokine assay at −70°C.

**Interferon γ (IFNγ) and interleukin 4 (IL4) assay**
Cytokine levels in culture supernatants were measured using an enzyme immunoassay (EuroClone, Devon, UK) according to the procedure suggested by the manufacturers. A standard curve was used to quantify the levels of both IFNγ or IL4. The lowest sensitivity was <5 pg/ml for IFNγ and <0.5 pg/ml for IL4 assay.

**Assay for cow’s milk protein antibodies**
Duplicate serum samples were tested for antibodies to βC and βLG by solid phase enzyme immunoassay. Wells of flat bottom microtitre plates (Costar, Cambridge, MA) were coated with 100 µl of the antigens at a concentration of 1 µg/well in

**Abbreviations:** βC, β-casein; BD, Behçet’s disease; βLG, β-lactoglobulin; CD, coeliac disease; ELISA, enzyme linked immunosorbent assay; IFN, interferon; IL, interleukin; OA, chicken egg albumin; PBMC, peripheral blood mononuclear cells; PHA, phytohaemagglutinin
carbonate-bicarbonate buffer, pH 9.6. Additional wells were coated with OA at a concentration of 1 µg/well by the same procedure and used to investigate the prevalence of antibodies against other unrelated food antigens. Results were expressed as standard deviation units according to the formula 

\[
\frac{X - M}{SD}
\]

where \(X\) is the absorbance of the test specimen, \(M\) is the mean absorbance of a basic set of 20 blood donor serum samples, and \(SD\) their standard deviation. A result above three standard deviation units was considered to be positive. The enzyme linked immunosorbent assay (ELISA) was reproducible with a coefficient of variation within plates of 5% and between plates of 9% for low and medium antibody levels and 8% and 11%, respectively, for high antibody levels. Specificity in the binding was assessed by incubating positive and negative sera with different concentrations (2, 5, 10 µg) of the antigens or phosphate buffered saline for one hour at 37°C before testing in the specific antibody assay. Total serum IgG and IgA were also measured by standard radial immunodiffusion assay (Istituto Behring, Italy).

RESULTS

Th1/Th2 cytokine levels

Figures 1 and 2 show the results obtained. Cytokines were measured in supernatants of PBMC cultures from 16 patients with active BD, 12 patients with inactive BD, 10 healthy subjects, and from a group of six patients with Crohn’s disease and 16 patients with CD. Quantitative determination of Th1/Th2 cytokines in supernatants of PBMC cultured in the presence of PHA or of increasing amounts of \(\beta\)-lactoglobulin (\(\beta\)LG), \(\beta\)-casein (\(\beta\)C), and chicken egg albumin (OA).

Cow’s milk proteins antibodies

Table 1 shows the number of subjects with antibody positive results, their binding reactivity, and statistics. The IgG and IgA binding to \(\beta\)LG and \(\beta\)C was significantly higher in patients
with active BD than in either patients with inactive BD (p<0.05) or healthy controls (p<0.01). No relation was seen between the occurrence of anti-βLG and the age of the patients, the duration of disease, the presence of gastrointestinal abnormalities, or the severity score of the disease (not shown). Binding to OA was low in patients both with active and inactive BD, and no positive results were found in either patients with BD or controls. Increased antibody levels against all dietary antigens (OA included) were seen in all the patients with CD and in two of the patients with Crohn’s disease. To determine whether the increase in βC and/or βLG binding activity was specific the inhibition tests were performed with a group of positive and negative serum samples. Sera were tested in the enzyme immunoassay before and after incubation with different amounts of purified antigens, phosphate buffered saline, or an unrelated protein (human albumin). No inhibitory effect was noticed when human albumin was used in the inhibition study. Low concentrations of βC were sufficient to inhibit anti-βC in their binding to βC coated solid phase in two of the serum samples studied. Medium/large amounts of βCo or βLG were necessary to obtain an inhibition in the other studied sera (four).

### Table 1

<table>
<thead>
<tr>
<th>Subjects</th>
<th>n</th>
<th>IgG (SD)</th>
<th>IgA (SD)</th>
<th>IgG (SD)</th>
<th>IgA (SD)</th>
<th>IgG (SD)</th>
<th>IgA (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active BD</td>
<td>28</td>
<td>1.72 (2.70)</td>
<td>2.07 (2.5)</td>
<td>3.64 (5.93)</td>
<td>1.89 (1.2)</td>
<td>0.81 (0.67)</td>
<td>0.62 (0.48)</td>
</tr>
<tr>
<td>Inactive BD</td>
<td>18</td>
<td>0.37 (0.65)</td>
<td>0.7 (1.12)</td>
<td>0.83 (1.26)</td>
<td>0.68 (0.92)</td>
<td>0.72 (0.76)</td>
<td>0.50 (0.40)</td>
</tr>
<tr>
<td>Crohn’s disease</td>
<td>6</td>
<td>1.86 (1.48)</td>
<td>1.53 (1.48)</td>
<td>2.1 (1.8)</td>
<td>1.38 (1.48)</td>
<td>1.6 (1.4)</td>
<td>1.2 (1.5)</td>
</tr>
<tr>
<td>Coeliac disease</td>
<td>16</td>
<td>5.8 (2.10)</td>
<td>4.2 (1.3)</td>
<td>3.8 (1.5)</td>
<td>3.5 (0.8)</td>
<td>4.8 (1.6)</td>
<td>3.6 (0.9)</td>
</tr>
<tr>
<td>Normal controls</td>
<td>37</td>
<td>0.59 (0.07)</td>
<td>0.47 (0.58)</td>
<td>0.83 (1.10)</td>
<td>0.48 (0.70)</td>
<td>0.6 (0.3)</td>
<td>0.5 (0.3)</td>
</tr>
</tbody>
</table>

### Immunoglobulin levels

Levels of total IgG were 13.28 (2.44) g/l in the anti-cow’s milk positive and 1.285 (3.28) g/l in the anti-cow’s milk negative sera (NS, Student’s t test). Levels of total IgA were 2.88 (0.32) g/l in positive and 2.67 (0.34) g/l in negative sera (NS, Student’s t test).

### DISCUSSION

Our study shows that exposure to cow’s milk proteins elicits the in vitro production of the Th1 cytokine IFNγ by peripheral blood mononuclear cells from patients with active BD. Similar results were obtained in Crohn’s disease (also considered a Th1 disease) but not in CD and healthy subjects.
Type 1 helper T cells and type 2 helper T cells are well known to be two extremely polarised forms of the effector specific immune response, based on a distinctive profile of cytokine production; the importance of Th1/Th2 balance in the emergence of autoimmunity has been also emphasised.

To protect the host from undesired immune response against proteins derived from food, oral tolerance must be induced by the intestinal immune system. Although intestinal intraepithelial lymphocytes expressing T cell receptor αβ or γδ produce a similar array of cytokines of the Th1 and the Th2 type, evidence has been presented that γδ intraepithelial lymphocytes in the gut abrogate oral tolerance. In most studies Th1 cytokines, in particular IFNγ, have been shown to be produced by stimulated γδ T lymphocytes. An increased number of activated circulating γδ T lymphocytes are present in most patients with active BD included in this study, but at present the role of γδ T cells in cow’s milk immune response is under investigation. Meanwhile, the data reported here support the recent hypothesis by Frassanito et al of a Th1 polarisation in the pathogenesis of BD.

Patients in an active stage of the disease have an enhanced frequency of antibodies directed against cow’s milk proteins (βLG and βC) not correlated with the severity score of disease, but not against other dietary antigens. The reason for these immunological abnormalities in BD is still unclear. The presence of anti-βC or anti-βLG may reflect the loss of self tolerance to cow’s milk proteins or be the result of gastrointestinal abnormalities. Increased uptake of dietary antigens may be a putative factor in the emergence of auto-reactivity in CD and Crohn’s disease. On the other hand, in BD, antibodies to cow’s milk protein occurred in the absence of antibodies directed against other dietary antigens—namely, OA, rendering the last hypothesis unlikely. Large amounts of free antigens were necessary to obtain an inhibitory effect in ELISA competition studies, suggesting that reactivity between anti-βC or anti-βLG and their antigens is at low affinity. In particular, low levels were found not only in normal subjects in our study but also in various autoimmune diseases, suggesting that they may represent a component of the normal immune repertoire. Natural autoantibodies have an important regulatory role in the maintenance of immune homeostasis. Increased titres of such antibodies are present in several autoimmune disorders, both systemic and organ-specific, usually with clonal expansion confined to a few autospecificities. Immune complexes formed with these autoantibodies may also have a physiological role in the immune system, delivering activation or tolerisation signals to autoreactive cells (reviewed by Guarinotta et al.).

An intriguing concept may also be that cow’s milk components exert detrimental effects on gut or on systemic immunoreactivity, leading to disturbed peripheral tolerance mechanisms or enhanced susceptibility to viral infections, or both. Upon digestion, several caseins may give rise to opioid peptides, which bind to opiate receptors on immune cells leading to modulation of T cell and macrophage reactivity, a further destabilising oral tolerance mechanism. A diet rich in cow’s milk might provide also antigens that elicit an immune response cross reactivity with self, thereby overcoming peripheral self tolerance. Such mimicry of the peptides would also be available from intestinal flora, in particular the highly immunogenic microbial heat shock proteins that have high relevance in the pathogenesis of BD.

In conclusion, the occurrence of antibodies to cow’s milk protein in BD, and studies on the cellular immune response with Th1 cytokine secretion, reported in this paper may support the putative role of cow’s milk proteins immune response in the pathogenesis of BD.

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