Serum copper and its relationship to clinical symptoms in rheumatoid arthritis


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SUMMARY Total serum copper and ultrafilterable copper levels in patients with rheumatoid arthritis were determined and related to articular index, erythrocyte sedimentation rate (ESR), and serum iron concentration. Relationships were found between serum copper and ESR, and between ultrafilterable copper and articular index. The relationship between serum copper and serum iron was found to be a drug-dependent.

The role of copper in rheumatoid arthritis has recently been of interest because of the abnormally high copper levels in the serum of patients with the disease (Bajpayee et al., 1975; Scudder et al., 1978), the greater anti-inflammatory activity of copper complexes of anti-inflammatory drugs (Sorensen, 1976), and a recent investigation of the persistent traditional use of copper bangles in the treatment of rheumatoid arthritis (Walker and Griffin, 1976). We report here our findings from a survey of over 100 patients with rheumatoid arthritis receiving different forms of therapy. In all cases the total serum copper concentration was estimated, and in a limited number the ultrafilterable copper level (using a cut-off of 1000 Dalton molecular weight) was determined by a newly developed method (Kamel et al., 1978).

Patients and methods

One hundred and twenty patients (mean age 53.0 ± SEM 4.8 years), of whom 50 were male, were studied. All were suffering from classical or definite rheumatoid arthritis as defined by the criteria of the American Rheumatism Association (Ropes et al., 1959). The mean duration of their disease was 9 years ± SEM 0.8 years. All patients had radiological evidence of articular erosions, and in 70 patients the serological tests for IgM rheumatoid factor were significantly positive.

Total serum copper ultrafilterable copper were estimated by atomic absorption spectrometry using carbon furnace atomisation (Kamel et al., 1978). Pellican membranes (molecular weight cut-off, 1000) were used for ultrafiltration. Since the salt content depresses the copper signal, saline standards are required together with careful adjustment of the background corrector and, owing to the low copper concentration, considerable care to avoid contamination. Serum iron and total iron binding capacity were measured with ferrozine (Technicon AA II Method SF4—0025 FL 4), total protein by means of biuret (Technicon AA II Method N14a), and erythrocyte sedimentation rate by Westergren’s method.

The articular index of joint tenderness (0 to 78 score units (Ritchie et al., 1968) was measured in each patient by a physician and amanuensis.

Results

COPPER IN SERUM

The major copper containing constituent in serum is caeruloplasmin. Our results agree with those of Scudder et al. (1978) in that the total serum copper mean in patients with rheumatoid arthritis (23.4 ± 5.13) was significantly higher than that of the controls (16.06 ± 3.93) and that except in the few cases of very high serum copper (greater than 31 μmol/l) the caeruloplasmin portion as measured by its oxidase activity accounted for about 90% of the total serum copper. Using a membrane with a molecular weight cut-off of 1000 we found a mean copper level in the ultrafiltrate of 0.85 μmol/l and a range from 0.047 to 1.458 μmol/l. Small amounts of copper were possibly present in other protein fractions, but these were too close to the sensitivity limit of the methods used to give
meaningful results. Occasional serum samples from females, both normal and rheumatoid, produced different distributions of copper, but these have not yet been fully elucidated and have not been included in any of the mean values cited.

**Copper Variations and Drug Therapy**

All the subjects in each group had been treated with the drug for at least 1 month prior to analysis of the sample for copper. The results in Table 1 suggest that there is a significant correlation between caeruloplasmin copper and drug therapy. For treatment with penicillamine and with steroids there is surprisingly good agreement with published results (Scudder et al., 1978).

**Copper Levels and Clinical Parameters**

In 100 patients the articular index measurements showed a slight but significant correlation with total serum copper and in 20 patients a much more significant correlation with ultrafilterable copper (Table 2).

In 90 patients a correlation was found between total serum copper and ESR, but in this case the correlation with ultrafilterable copper was much less significant.

A strong inverse correlation between serum iron and serum copper has been described in patients with rheumatoid arthritis (Scudder et al., 1978). In a sample of 135 patients, of whom 50 were on levamisole therapy, we did not find any significant correlation (Table 2). However, if the levamisole treated patients were not included, a significant inverse relationship was found (r = -0.348, P < 0.001). Levamisole treated patients (n = 50) did not show a significant correlation with serum iron. The D-penicillamine treated group also failed to show a significant inverse correlation.

**Table 1** Total serum copper with different drugs (μmol/l)

<table>
<thead>
<tr>
<th>Type</th>
<th>Mean ± SD</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steroids</td>
<td>23.46 ± 4.56</td>
<td>11</td>
</tr>
<tr>
<td>D-penicillamine</td>
<td>20.70 ± 2.83</td>
<td>18</td>
</tr>
<tr>
<td>Simple analgesics</td>
<td>25.98 ± 3.14</td>
<td>50</td>
</tr>
<tr>
<td>Levamisole</td>
<td>22.67 ± 4.4</td>
<td>50</td>
</tr>
<tr>
<td>Controls</td>
<td>16.06 ± 3.93</td>
<td>30</td>
</tr>
</tbody>
</table>

**Table 2** The relationship of total copper and ultrafilterable copper levels in serum to erythrocyte sedimentation rate (ESR), articular index (AI), iron level, and % saturation of iron (SATN) in serum

<table>
<thead>
<tr>
<th>Articular index</th>
<th>ESR</th>
<th>Fe</th>
<th>SATN (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total serum copper</td>
<td>n = 100</td>
<td>r = 0.2256</td>
<td>n = 135</td>
</tr>
<tr>
<td>Ultrafilterable copper</td>
<td>n = 20</td>
<td>r = 0.746</td>
<td>n = 15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean total copper</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with ESR &gt; 30</td>
<td>n = 35</td>
</tr>
<tr>
<td>&quot; &quot; ESR ≤ 30</td>
<td>n = 50</td>
</tr>
<tr>
<td>&quot; &quot; AI &gt; 30</td>
<td>n = 22</td>
</tr>
<tr>
<td>&quot; &quot; AI ≤ 30</td>
<td>n = 80</td>
</tr>
<tr>
<td>&quot; &quot; Fe ≤ 13</td>
<td>n = 98</td>
</tr>
<tr>
<td>&quot; &quot; Fe &gt; 13</td>
<td>n = 58</td>
</tr>
</tbody>
</table>

If arbitrary values of ESR, articular index, and serum iron are taken to mark a dividing line between 'severe' and 'not severe' rheumatoid arthritis, as shown in Table 3, the mean total serum copper levels were greater in the 'severe' category.

**Discussion**

Most serum copper is contained in caeruloplasmin with small amounts associated with other proteins and low molecular weight fractions. The biological activities, if any, of the latter fractions in vivo are not known, mainly because their concentrations are difficult to determine. Various methods of determining the copper level in these fractions have been employed, but all have drawbacks (Kamel et al., 1978). In particular the determination of the copper in all these fractions by subtraction of the caeruloplasmin copper level from the total serum level seems to us to be unrealistic in view of the low copper levels and ligands associated with copper contamination from the chemicals and equipment used. Further, copper levels in caeruloplasmin can be determined either by calculation after analysis for the protein by immunoelectrophoresis, or as an oxidase, or by direct determination of the copper content. These are obviously closely related, but how precisely is as yet uncertain. In this study we analysed directly for ultrafiltrate and compared the levels obtained together with total serum copper levels to clinical parameters measured at the same
time. Our results indicate that there is no simple relationship between total serum copper and ultrafilterable copper levels, and therefore that the ultrafiltrate is probably not in direct equilibrium with copper or albumin, though it seems likely. Thus the ultrafilterate copper and the caeruloplasmin copper levels might be related differently to the usual clinical parameters. This is essentially what we found, in that the ultrafilterable copper showed a significant correlation with articular index whereas the total serum copper showed a much less significant correlation. The ultrafilterable copper showed no significant correlation with ESR measurements, whereas the total copper did show a significant correlation. Thus when talking of serum copper, at least 2 measurements should be considered —caeruloplasmin and low molecular weight compounds of copper. Any relationship between the ultrafilterable copper and the reported high urinary concentration of copper in rheumatoid arthritis (McMurray et al., 1975) has not yet been established.

The other variable which has emerged is the effect of different drugs on total serum copper and ultrafilterable copper levels and on the clinical parameters articular index, serum iron, and ESR. Further work is necessary to assess the importance of the 2 copper estimations in different drug therapies.

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References