Platelet derived malonyldialdeyde production in patients with thalassaemia major

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SUMMARY Malonyldialdehyde, a product of membrane lipid peroxidation, was measured in the platelets of 16 normal subjects after stimulation with a variety of aggregating and stimulating agents. Nethylnaleimide and hydrogen peroxide generated the largest amounts of malonyldialdehyde. These agents were used to stimulate platelets from 11 patients with thalassaemia major suffering from iron overload due to repeated transfusion. Mean malonyldialdehyde concentrations were the same in normal subjects as in thalassaemic patients, but high concentrations were recorded in patients with severe iron overload. There was a highly significant correlation between malonyldialdehyde and serum ferritin concentrations in all thalassaemic patients. Platelet derived malonyldialdehyde may be a useful test of continuing membrane damage in patients with iron overload.

Lipid peroxidation of cell membranes is associated with a number of pathological conditions, such as radiation damage to the lungs, liver injury, atherosclerosis, and thrombosis and many inflammatory processes. Malonyldialdehyde, a stable secondary product of lipid peroxidation, can be measured after oxidant stress. With this technique red cells have been shown to be more susceptible to autodisruption in autoimmune haemolytic anaemia and \( \beta \)-thalassaemia major. Iron salts are among the most potent catalysts of lipid peroxidation, and high red cell malonyldialdehyde concentrations found in patients who have had multiple transfusions may reflect the damage to other organs caused by excess iron. In patients with \( \beta \)-thalassaemia major it is difficult to correlate red cell malonyldialdehyde concentrations with membrane damage in other tissues as many of these cells are transfused, producing inappropriately low values, and thalassaemic red cell membranes contain large amounts of lipid susceptible to autodisruption compared with normal cells.

Malonyldialdehyde is also formed in platelets during the non-enzymatic peroxidation of polyunsaturated fatty acids and enzymatically during prostaglandin production. There has been one previous report of abnormal platelet function in \( \beta \)-thalassaemia major. We have therefore investigated malonyldialdehyde generation in the platelets of normal subjects and repeatedly transfused patients with \( \beta \)-thalassaemia major on exposure to oxidant stress with hydrogen peroxide and on activation with nethylnaleimide, an agent used to assess platelet activation in vitro. We have also correlated platelet malonyldialdehyde production with the degree of iron overload assessed by serum ferritin.

Material and method

Twenty millilitres of venous blood was collected into 3.13% sodium citrate and centrifuged at 150 g for 15 min at 20°C. The supernatant platelet poor plasma was then inverted for 2 min to remove all plasma, and the platelet buttons were resuspended in 0.9 ml of phosphate buffered saline (PBS). Malonyldialdehyde generation was measured after stimulation with adenosine diphosphate, adrenaline, collagen, ristocetin, nethylnaleimide, and hydrogen peroxide.

To four of the tubes we added 100 \( \mu l \) of one of the stimulating agents and to the fifth we added 100 \( \mu l \) of PBS as a blank. The suspensions were then incubated for 60 min at 37°C in a waterbath. After incubation 1 ml of the 2-thiobarbituric acid solution was added to each tube, which was vortex mixed to terminate the reaction and then incubated for 30 min at 80°C. The tubes were then removed, cooled on ice, and centrifuged at 2000 g for 15 min at 4°C. The optical density of the supernatant was read at 532 nm against the appropriate blank, and the concentration of malonyldialdehyde was calculated as follows:

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nmol malonyldialdehyde per 10⁹ platelets = \( \frac{A \cdot Vi \cdot E}{N \cdot Vi \cdot E} \times 10⁹ \)

where \( A \) = optical density at 532 nm, \( Vi \) = final volume (1 ml), \( Vi \) = initial volume (0-9 ml), \( N \) = platelet count (platelet rich – platelet poor plasma), and \( E \) = molar extinction coefficient of malonyldialdehyde (1.55 \( \times \) 10⁹).

**Results**

Malonyldialdehyde concentrations were measured in 16 healthy volunteer subjects (age range 18-30 years) and 11 patients with transfusion dependent thalassaemia major (age range 16-25 years) who were attending the thalassaemia clinic at University College Hospital. Serum ferritin concentrations were measured in samples taken on the same day as the malonyldialdehyde measurements were performed.

**Patients**

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**Discussion**

In this study we assessed the ability of several platelet stimulating agents to induce malonyldialdehyde release from the platelets of normal subjects and of patients suffering from thalassaemia major. In platelets from patients with \( \beta \)-thalassaemia, mean malonyldialdehyde concentrations were normal, but there was a close correlation between platelet

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**Table 1**  *Effects of various stimulating agents on malonyldialdehyde generation from platelets from 16 normal subjects*

<table>
<thead>
<tr>
<th>Stimulating agent (concentration)</th>
<th>Malonyldialdehyde concentration (nmol/10⁹ platelets) ±2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nethyinleimide (1 mM)</td>
<td>1.05 ± 0.25*</td>
</tr>
<tr>
<td>Hydrogen peroxide (10mM)</td>
<td>0.85 ± 0.33</td>
</tr>
<tr>
<td>Ristocetin (12 mg/ml)</td>
<td>0.46 ± 0.04</td>
</tr>
<tr>
<td>ADP (10 μM)</td>
<td>0.14 ± 0.02</td>
</tr>
<tr>
<td>Adrenaline (1 mg/ml)</td>
<td>0.08 ± 0.02</td>
</tr>
<tr>
<td>Collagen (1 μg/ml)</td>
<td>0.05 ± 0.01</td>
</tr>
</tbody>
</table>

*Values given as mean ± 2 SD.

**Table 2**  *Malonyldialdehyde (nmol/10⁹ platelets) generated from platelets from patients with \( \beta \)-thalassaemia major*

<table>
<thead>
<tr>
<th>Patient no</th>
<th>Nethyinleimide (1-0 mM)</th>
<th>Hydrogen peroxide (10 mM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.09 ± 0.06*</td>
<td>0.78 ± 0.15</td>
</tr>
<tr>
<td>2</td>
<td>1.78 ± 0.11</td>
<td>1.10 ± 0.23</td>
</tr>
<tr>
<td>3</td>
<td>2.61 ± 0.02</td>
<td>1.75 ± 0.11</td>
</tr>
<tr>
<td>4</td>
<td>0.66 ± 0.05</td>
<td>ND</td>
</tr>
<tr>
<td>5</td>
<td>1.15 ± 0.13</td>
<td>ND</td>
</tr>
<tr>
<td>6</td>
<td>0.44 ± 0.04</td>
<td>0.62 ± 0.32</td>
</tr>
<tr>
<td>7</td>
<td>0.25 ± 0.03</td>
<td>0.10 ± 0.07</td>
</tr>
<tr>
<td>8</td>
<td>1.77 ± 0.14</td>
<td>ND</td>
</tr>
<tr>
<td>9</td>
<td>0.57 ± 0.14</td>
<td>ND</td>
</tr>
<tr>
<td>10</td>
<td>ND</td>
<td>0.23 ± 0.09</td>
</tr>
<tr>
<td>11</td>
<td>0.40 ± 0.02</td>
<td>0.34 ± 0.17</td>
</tr>
<tr>
<td>Normal subjects (mean)</td>
<td>1.05 ± 0.25</td>
<td>0.85 ± 0.33</td>
</tr>
<tr>
<td>Thalassaemia major (mean)</td>
<td>1.07 ± 0.73</td>
<td>0.70 ± 0.53</td>
</tr>
</tbody>
</table>

*Values given as mean ± 2 SD.

ND = not done.

**Discussion**

In this study we assessed the ability of several platelet stimulating agents to induce malonyldialdehyde release from the platelets of normal subjects and of patients suffering from thalassaemia major. In platelets from patients with \( \beta \)-thalassaemia, mean malonyldialdehyde concentrations were normal, but there was a close correlation between platelet

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**Concentrations of platelet derived malonyldialdehyde and serum ferritin in patients with thalassaemia major.**
malondialdehyde values and serum ferritin concentrations whether hydrogen peroxide or nethylmaleimide was used as the stimulating agent. The highest malondialdehyde concentrations were recorded in patients who not only had considerably raised serum ferritin concentrations but also had other signs of iron overload. As platelet associated malondialdehyde provides a measure of lipid peroxidation of cell membranes, the raised concentrations found in the most heavily iron overloaded patients may therefore reflect increased iron mediated cell membrane damage; such high values may be associated with increased quantities of free iron or that loosely bound in the postulated toxic iron pool.20

Serum ferritin concentrations closely correlate with total and hepatic iron stores,21 and in the well chelated, iron overloaded patient much of the transfused iron is sequestered in a relatively inert form22,23 and plays a comparatively small part in continuous iron mediated membrane damage. In grossly iron overloaded patients, however, or in those patients who comply poorly with desferrioxamine treatment, there may be sufficient iron in an active form to cause increased membrane lipid peroxidation and consequent tissue damage. High concentrations of platelet malondialdehyde may be recorded only in these patients, and our data suggest that values outside the normal range are indeed obtained in patients who show signs of iron toxicity in addition to raised serum ferritin concentrations.

Clinical improvement in iron overloaded thalassaemia patients may be brought about by increasing the dosage of desferrioxamine24 and deterioration may follow administration of large amounts of vitamin C,25 with comparatively minor changes in serum ferritin; this suggests that the serum ferritin concentration is not an adequate measure of continuing organ damage.

We conclude that the use of stimulated platelet malondialdehyde concentrations provides a useful, simple measure of lipid peroxidation and consequent cell membrane damage in chronically iron overloaded patients and that serial measurements may be a useful guide to clinical progress.

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References


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