A simplified method for the quantitative determination of urinary coproporphyrin in lead workers

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The estimation of urinary coproporphyrin is used in the assessment of inorganic lead absorption (Lane et al., 1968). Waldron (1971) found it to be a suitable screening test to monitor a lead hazard. The quantitative method of Rimington (1971) is satisfactory but time consuming, and we have found semiquantitative tests, based on the red fluorescence of coproporphyrin, difficult to interpret. The following procedure was therefore devised.

**Method**

**Reagents**
Glacial acetic acid. Anaesthetic ether. Hydrochloric acid (approximately 5g/100ml) 120 ml concentrated acid diluted to one litre with distilled water. 1% iodine in ethanol, stored at 4°C in the dark. Hydrochloric acid-iodine solution prepared freshly each day by mixing 1 ml 1% iodine and 200 ml 5% hydrochloric acid.

**Procedure**
Place 2 ml of mixed urine in a glass-stoppered tube (125 mm × 15 mm) and add acetic acid (0.2 ml) and anaesthetic ether (5 ml). Shake for 15 seconds and then allow the phases to separate. Remove the lower aqueous layer; add hydrochloric acid-iodine solution (5 ml) to the ether layer and shake for 15 seconds. Allow the phases to separate, remove the upper layer of ether, and place the unstoppered tube in a water bath at 37°C for 5 minutes. Re-stopper the tube and shake. Measure the optical density in a spectrophotometer, using a 1 cm cuvette, at wavelengths of 380 and 430 nm and at the peak of the Soret band (about 401 nm).

**Calculation of results**
If $D_{\text{max}}$ = optical density at peak of Soret band
$D_{430}$ = optical density at 430 nm
$D_{380}$ = optical density at 380 nm
Then

$$[2D_{\text{max}} - (D_{430} + D_{380})] \times 2.093 \times 1.064 = \text{mg coproporphyrin/litre}.$$

**Comparison with the method of Rimington (1971)**
One hundred random urine samples were collected from lead workers over a period of several months. Coproporphyrin estimations were carried out by the method of Rimington (1971) and by the simplified...
The results show two distinctive features. First, with urine coproporphyrin levels over 2.5 mg/l, the simplified method gave significantly lower answers than Rimington's method, giving a pronounced curve in the overall pattern of the results. For clinical use the exact value of these high concentrations is not very important, so for the purposes of fitting a suitable equation these high values were ignored.

Secondly, the variance of the observations increases with increase of the concentration of coproporphyrin. Consequently, a weighted least squares analysis was used to fit a straight line through the origin.

The regression details are as follows:

Regression equation $Y = 0.939X$
Coeficient of correlation $= 0.986$
No. of observations $= 94$

Standard error of slope of regression line $= 0.014$
Standard error about the line $= \sqrt{X/10}$

The slope of the regression line (0.939) differs significantly from 1 ($p < 0.05$).

The variance between duplicates for both methods increases with the concentration of coproporphyrin in the samples. For the simplified method the variance between duplicates (over the range 0-2.5 mg/l) was approximately equal to X/1000 which was about half that for the Rimington method.

**Discussion**

The main differences between this method and that of Rimington (1971) are as follows. Single extractions are used instead of repeated extractions. This would account for the fact that the simplified method gave, in general, lower results than Rimington's method. To allow for this it is suggested that, in calculating the results, the factor of 2.093 used by Rimington is multiplied by 1.064, the reciprocal of the factor obtained in the regression equation.

The sodium acetate wash was omitted, for in no sample during the execution of Rimington's method did the acetate wash show any red fluorescence under ultraviolet light. The iodine and hydrochloric acid were combined into one reagent. The excess iodine passed into the ether layer and was removed. Warming the acid solution to 37°C removed dissolved ether. Without this step, bubbles sometimes formed during the photometric readings.

Optical density readings for this comparative investigation were made manually. A more rapid method is to scan the acid extract over the range 380-430 nm in a recording spectrophotometer. The height of the peak above the baseline can be measured with a scale calibrated directly in milligrammes coproporphyrin per litre. Using this method, 100 estimations can easily be carried out by a single worker in one day.

Rimington's method and the simplified method were applied to two urine specimens from two cases with different diagnoses. The results are shown in the Table below.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Urine coproporphyrin (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rimington's method</td>
</tr>
<tr>
<td>Lead worker</td>
<td>3.269</td>
</tr>
<tr>
<td>&quot; &quot; &quot;</td>
<td>3.576</td>
</tr>
<tr>
<td>&quot; &quot; &quot;</td>
<td>3.677</td>
</tr>
<tr>
<td>&quot; &quot; &quot;</td>
<td>4.377</td>
</tr>
<tr>
<td>&quot; &quot; &quot;</td>
<td>6.391</td>
</tr>
<tr>
<td>&quot; &quot; &quot;</td>
<td>7.075</td>
</tr>
<tr>
<td>Acute intermittent porphyria</td>
<td>1.010</td>
</tr>
<tr>
<td>Acute intermittent porphyria</td>
<td>0.310</td>
</tr>
</tbody>
</table>

The correction factor of 1.064 has not been applied to the values for the simplified method.
of acute intermittent porphyria. The results are shown in the Table. These results throw doubt on the reliability of the simplified method in cases of porphyria, although the second urine had been stored for six weeks before examination.

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References

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