The association of the slow acetylator phenotype with bladder cancer

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SUMMARY There is an association between exposure to aromatic amines and the development of bladder cancer. Aromatic amines such as are known to occur in tobacco smoke are polymorphically acetylated. One hundred bladder cancer patients have been acetylator phenotyped. Only three of them were non-smokers at the time of diagnosis. This new series, together with four previous series (each with its own control), have been statistically analysed together.

The result shows a significant association between the slow acetylator phenotype and bladder cancer. The slow acetylator phenotype is associated about 39% more with bladder cancer than is the rapid acetylator phenotype. This association can be interpreted in one of two ways: (1) rapid acetylators may be protected against developing bladder cancer because they are better able to render amines non-carcinogenic by acetylation, or (2) slow acetylators have greater survival with bladder cancer than rapid acetylators. Further evidence will be required to differentiate between these alternatives.

A key biological puzzle is to understand how a known environmental agent reacts with a genetic polymorphism in such a manner that some subjects of a given phenotype are more prone to develop a particular disorder. Bladder cancers are known to occur at a higher rate in subjects exposed to aromatic amines either in tobacco smoke or in their occupations.¹

It has been found in both human and rabbit populations that some carcinogenic aromatic amines (for example, amino-fluorene, benzidine, and 2-naphthyl-amine) are polymorphically acetylated by the same N-acetyl-transferase that is responsible for the polymorphic acetylation of a number of drugs.²³ In this genetic polymorphism slow acetylation is an autosomal recessive phenotype.⁴ These considerations have led to the suggestion that the two human acetylator phenotypes may differ in their predisposition to develop neoplastic disorders believed to be caused by aromatic amines. This idea is based on an analogy with the now established fact that genetic constitution can predispose to drug toxicity.⁵ An obvious example to test the hypothesis is bladder cancer.

Three previous publications⁶–⁸ give information on acetylator phenotypes of bladder cancer patients. More information is needed to reach a valid conclusion. This article reports the acetylator phenotypes...

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TABLE 1  Bladder cancer patients subdivided by clinical criterion and acetylation phenotype.

<table>
<thead>
<tr>
<th>Clinical criterion</th>
<th>Slow acetylators</th>
<th>Rapid acetylators</th>
<th>$\chi^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>6</td>
<td>2</td>
<td>0.029</td>
</tr>
<tr>
<td>50 and over</td>
<td>60</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>45</td>
<td>29</td>
<td>0.057</td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;20 cigs/day</td>
<td>29*</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>&lt;20 cigs/day</td>
<td>31</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Industrial exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has occurred</td>
<td>11†</td>
<td>8</td>
<td>0.943</td>
</tr>
<tr>
<td>Has not occurred</td>
<td>44</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Bladder cancer†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 1</td>
<td>40</td>
<td>20</td>
<td>0.16</td>
</tr>
<tr>
<td>Grades 2, 3, 4</td>
<td>20</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

For each row $p < 0.10$.

Table 1: Bladder cancer patients subdivided by clinical criterion and acetylation phenotype. The table shows the distribution of patients with slow and rapid acetylation for different clinical criteria such as age at diagnosis, sex, smoking status, industrial exposure, and the occurrence of bladder cancer. The statistical significance of each criterion is indicated by the $\chi^2$ value.

Materials and methods

The phenotyping procedure used was method II of Evans, which involves giving one oral dose of sulphadimidine (syn: sulfamethazine) and taking one blood and one urine specimen for analysis. The laboratory analytical procedure was carried out as described by Eze and Evans.

Results

One hundred patients were phenotyped (figure). The pattern of the percentage acetylation of sulphadimidine in plasma and urine closely resembled that published for normal subjects (see, for example, Viznerova et al).

Sixty-six patients were slow acetylators giving as the frequency of the recessive allele $q = 0.81$ se $(q) = 0.03$ (see Karim et al for comparative data). The mean age at diagnosis was not significantly different

TABLE 2  Test of association between bladder cancer and acetylator phenotype. (Modification by Haldane)

<table>
<thead>
<tr>
<th>Reference</th>
<th>No of subjects</th>
<th>Approximate relative risk $x$</th>
<th>$\log_{10} x$</th>
<th>Sampling variance $V$</th>
<th>Weight $l$</th>
<th>Significance of difference from zero $w$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Rapid Slow Rapid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower et al* Danish*</td>
<td>46</td>
<td>25</td>
<td>38</td>
<td>36</td>
<td>1.728</td>
<td>0.5474</td>
</tr>
<tr>
<td>Slow Rapid Slow Rapid</td>
<td>80</td>
<td>35</td>
<td>79</td>
<td>39</td>
<td>1.127</td>
<td>0.1193</td>
</tr>
<tr>
<td>Cartwright et al†</td>
<td>74</td>
<td>37</td>
<td>118</td>
<td>89</td>
<td>1.4921</td>
<td>0.4002</td>
</tr>
<tr>
<td>Woodhouse et al*</td>
<td>21</td>
<td>9</td>
<td>16</td>
<td>13</td>
<td>1.8517</td>
<td>0.6161</td>
</tr>
<tr>
<td>Present series</td>
<td>66</td>
<td>34</td>
<td>5108</td>
<td>342</td>
<td>1.2932</td>
<td>0.2571</td>
</tr>
</tbody>
</table>

The weighted mean value of $y = wy/ \sum wy = 20.7268/62.9824 = 0.3290$.

Significance of difference of $X$ from unity $= \chi^2_{x=1} = (\Sigma wy)^2/\Sigma w = 6.8170 (p < 0.01)$.

Heterogeneity is tested by $\chi^2 = \Sigma wy(2-78 \times 0.126) = 0.6793$ and $0.0213$.

The equivalent $X$ values to the 95% fiducial limits of $Y$ are $1.9725$ and $0.9789$.

Weighted mean value of $y = wy/ \sum wy = 20.7268/62.9824 = 0.3290$.

SE of $Y = (\Sigma wy)^{1/2} = 0.1260$.

Significance of difference of $X$ from unity $= \chi^2_{x=1} = (\Sigma wy)^2/\Sigma w = 6.8170 (p < 0.01)$.

Heterogeneity is tested by $\chi^2 = \Sigma wy(2-78 \times 0.126) = 0.6793$ and $0.0213$.

*Technique of phenotyping: Weber and Brenner.
†Technique of phenotyping: monooctyl dapsone/dapsone ratio in plasma.
‡Technique of phenotyping: plasma isoniazid halflife.
§Pooled Liverpool control data.
in the two phenotypes (57.3 years in the slow and 58.6 in the rapid).

These patients have been sub-divided in relation to various characteristics (sex, age, smoking, history of industrial exposure, and histological type of bladder neoplasm) (table 1). In no case was there any hint of association with the acetylator polymorphism. At the time of diagnosis only three patients were non-smokers. There are no satisfactory control data available on the relationship between smoking habits and the acetylator polymorphism. Several retrospective studies have indicated that cigarette smokers have approximately twice the risk of non-smokers of cancer of the bladder. Positive industrial exposure was principally in the chemical and rubber industries were amines are known to have been employed. The 19 persons deemed to have been 'exposed' had worked in the rubber and chemical industries for varying periods most for many years. Two had worked in these industries for less than 7 years, one for 5 months, and one for 12 months.

The present results, together with four previously available series, have been examined by the method of Woolf as modified by Haldane (table 2).

Suitable control information for the present bladder cancer patients has been obtained by pooling data which have previously been published on several series of Liverpool white British subjects. There is a highly significant association between bladder cancer and the slow acetylator phenotype and there is no heterogeneity between the results from different series.

Discussion

The information shown in the figure closely resembles the results obtained when populations of healthy subjects have been phenotyped using the same technique, which is evidence indicating that any residual activity of bladder cancer did not interfere with the phenotyping test.

In studies of statistical associations of genetically determined phenotypes with disorders, the matter of selection is of importance. The Liverpool bladder cancer patients were people who had survived over a period and who lived in a defined area, so selection factors might have been introduced. It is possible that the survival factor might influence the results in other studies in table 2.

Another point of great importance is the nature of the control populations. Two separate sets of controls were studied by Lower et al. Each separate study has its own control group and the sets of controls were non-random and collected in different ways, one set to accompany the urban Copenhagen patients and another to accompany the rural Lund patients. In each case the controls were "healthy hospital personnel and hospital patients". A series of geriatric patients without malignant disease constituted the controls of Woodhouse et al. The London-based controls of Cartwright et al were "healthy subjects from Guy's Hospital", and the Huddersfield controls were either non-bladder cancer urological patients or "patients undergoing cold surgery for various conditions". The six Liverpool control series which were pooled comprised variously healthy medical students, healthy hospital and university staff, and tuberculous patients. It may be speculated that the lack of heterogeneity of the association between the series (table 2) is more convincing in view of the differing nature of the control groups.

Cartwright et al observed a strikingly high association between the slow acetylator phenotype and bladder cancer in Huddersfield dye workers. No such sub-group of occupational exposure could be defined in the present series where persons had been exposed to a wide variety of industrial chemicals. The association revealed in table 2 is clearly strengthened by the inclusion of the Huddersfield dye workers, but would still be statistically significant (p<0.05) if the data of Cartwright et al were omitted. Smoking would appear to be a more general environmental association (see table 1 for the data on smoking in the present series).

Table 2 reveals the slow acetylator phenotype to be about 39% more associated with bladder cancer than the rapid acetylator phenotype. Two possible interpretations follow. (1) Slow acetylators are more prone to develop bladder cancer than rapid acetylators. Carcinogenic amines (which occur in tobacco smoke) are known to be polymorphically acetylated. It is suggested, therefore, that the phenotype performing rapid acetylation of these amines may possess a degree of protection against the development of bladder cancer. (2) Slow acetylators have a greater survival with bladder cancer than rapid acetylators.

Obviously prevalence data will not allow either of these interpretations to be eliminated. It will be necessary to acetylator phenotype bladder cancer patients at the time of diagnosis in order to resolve the difficulty. The association shown in table 2 is sufficiently firm to justify such an undertaking.

Addendum

After this article had been submitted Miller (Miller ME. Acetylator phenotype in bladder cancer. Lancet 1982; ii: 1348) reported the acetylator phenotypes of 15 bladder cancer patients who had a
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positive occupational exposure to bladder carcinogens. Six were slow acetylators. There was no control group.

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References


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