cellular fluid would be the most likely sites to be alkylated by the acrylates.

In summary, the design of a drug such as atracurium that can undergo the Hofmann elimination represents a novel concept to limit its duration of action. It remains, however, to be shown that the acrylates formed pose no clinical threat.

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REFERENCES


(Accepted for publication December 7, 1983)

A Reconsideration of the Merits of the Cardiac Risk Index

To the Editor—In 1977, Goldman et al.¹ established a cardiac risk index (CRI) to estimate the probability of life-threatening or life-terminating cardiac complications (ventricular tachycardia, cardiogenic pulmonary edema, and/or new myocardial infarction) developing during or following noncardiac surgery (general, orthopedic, or urologic). Techniques of linear discriminant analysis found nine preoperative conditions that were good predictors of cardiac outcome in their study of 1,001 patients. The presence of each condition was weighted versus the others, with a score from 3 to 11 points; the maximum number of points for the presence of all nine conditions was 53. For ease of use, Goldman et al. subdivided the point totals into four ranges (Class I: 0–5; Class II: 6–12; Class III: 13–25; Class IV: ≥26). There was an increasing frequency of cardiac complications in ascending from Class I to Class IV. Goldman et al. mentioned the need for prospective studies in other patient populations to validate their risk index as a predictor of cardiac complications.

In a recent issue, Jeffrey et al.² prospectively evaluated 99 patients undergoing their first elective, abdominal aortic resection by calculating the cardiac risk index and then observing the actual outcome. In table 1, the outcome of Jeffrey et al. and Goldman et al. is contrasted.

As there were no Class IV patients in the study of Jeffrey et al., Class IV is not shown. Because of the statistically significant difference in outcome in Class I, Jeffrey et al. concluded that "... the CRI in its present form is not helpful in estimating cardiac risk in patients undergoing elective aortic surgery."

Mantel-Haenszel Chi-square Analysis is a form of frequency analysis that allows testing for linear trends.³ In both Jeffrey et al. and Goldman et al. there is a statistically significant relationship between increasing CRI and increasing frequency of cardiac complications (Goldman et al.,¹ Class I: 1%; Class II: 7%; Class III: 14%; MHX² = 56.7, P = 10⁻⁶; Jeffrey et al.,² Class I: 7%, Class II: 11%; Class III: 38%; MHX² = 4.6, P = 0.03). Mantel-

<table>
<thead>
<tr>
<th>Table 1. Comparison of Cardiac Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Class</td>
</tr>
<tr>
<td>No. Patients</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

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Haenszel Chi-square Analysis also allows a comparison of the frequency of cardiac complications between the two groups controlled for each of the three CRI classes; the patients of Jeffrey et al. have significantly more complications than those of Goldman et al. (Summary MHX² = 10.8, P = 0.001). A summary relative risk ratio also is calculable that shows that elective abdominal aortic surgery has more than three times (odds ratio = 3.19) as many cardiac complications than a more heterogenous group of surgical procedures. Thus the ability of the CRI to discriminate outcome (cardiac complications) has been demonstrated, although the group studied had three times higher risk of cardiac complications than the reference population.

I feel that the conclusion of Jeffrey et al.² is unduly harsh. Yes, there is a difference in complication rate between the heterogenous group in the original study and the more specific group studied by Jeffrey et al., but the general power of the CRI (increasing morbidity with higher scores) has been confirmed.

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In reply—We agree with Dr. Pace’s conclusion. The CRI¹ does show an increasing morbidity with higher scores. This again has been confirmed in a study by Dominguè et al.² (table 1). They evaluated a group of patients undergoing a variety of elective and emergency vascular surgical procedures. Their results were similar to ours. Each class showed a higher morbidity and mortality than would have been expected using Goldman’s population as a model.

The two points we wish to make are 1) patients who are evaluated using the CRI may have substantially different risk levels than indicated by the incidence of morbidity and mortality in Goldman’s study; 2) the trend of higher morbidity and mortality with higher scores has not been confirmed for nonvascular surgical procedures.

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References


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Table 1. A Comparison of Postoperative Cardiac Complications and Death between Goldman’s and Dominguè’s Populations

<table>
<thead>
<tr>
<th></th>
<th>Domainique</th>
<th>Goldman</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(6.0%)*</td>
</tr>
<tr>
<td>Life-threatening</td>
<td></td>
<td>(2.0%)</td>
</tr>
<tr>
<td>complications</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Sample size</td>
<td>50</td>
<td>537</td>
</tr>
<tr>
<td>Cardiac death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life-threatening</td>
<td></td>
<td>(8.8%)</td>
</tr>
<tr>
<td>complications</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Sample size</td>
<td>34</td>
<td>316</td>
</tr>
<tr>
<td>Cardiac death</td>
<td></td>
<td>(5.9%)*</td>
</tr>
<tr>
<td>Life-threatening</td>
<td></td>
<td>(31.2%)*</td>
</tr>
<tr>
<td>complications</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Sample size</td>
<td>16</td>
<td>130</td>
</tr>
<tr>
<td>Cardiac death</td>
<td></td>
<td>(18.7%)*</td>
</tr>
</tbody>
</table>

* P < 0.05 for comparison of incidence of this complication in the Domainique study versus its incidence in the study of Goldman et al. Probabilities calculated using the Poisson distribution.