sibly d-tubocurarine may be redistributed from inactive to active sites. Furosemide may have a stronger affinity for plasma and tissue proteins than does d-tubocurarine.11

In summary, these case reports suggest that furosemide and possibly mannitol augment d-tubocurarine-induced neuromuscular blockade. This is of particular significance to patients undergoing renal transplantation, since such patients already are at risk of prolonged neuromuscular blockade. We speculate that redistribution of d-tubocurarine and/or a direct depressant effect on the neuromuscular junction is the mechanism by which these diuretics augment the effect of d-tubocurarine.

REFERENCES


Another Hazard of Free-standing Vaporizers, Increased Anesthetic Concentration with Reversed Flow of Vaporizing Gas

William E. Marks, Jr., M.D.,* and J. Roger Bullard, M.D.*

Although Munson1 has pointed out that free-standing flow-through vaporizers present a hazard through the possibility of tipping, several of these units remain in use in our department for reasons of economy and convenience. We have recently recognized another hazard of these non-attached vaporizers, that of flowing the vaporizing gases through backwards.

Three times over the past five months, attending anesthesiologists have discovered these vaporizers set up in a reverse manner by residents and student nurse-anesthetists. Twice it was discovered prior to use of the equipment, and once during use. The Cyprane® vaporizers that we use can easily be set up by mistake to allow vaporizing gases to flow through them in a reverse direction. All that is required is to connect the delivery tube from the common gas outlet of the anesthesia machine to the outlet side of the vaporizer, and to connect the delivery tube to the patient’s breathing circuit to the inlet side of the vaporizer. Although the inlet and outlet sides of the vaporizer are labeled, the labeling is not conspicuous. The same size of tubing fits either side.

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An oxygen flow of 5 l/min was delivered to three free-standing vaporizers. Plastic tubing was used throughout. Three measurements of delivered anesthetic concentration were made at each vaporizer dial setting under conditions of proper and reverse flow, and the mean anesthetic concentration determined for each set of measurements. All measured values at the same dial setting and direction of gas flow were found to be within ±5 per cent of the mean anesthetic concentration for that set of measurements. The mean anesthetic concentrations are shown in Table 1.

Flowing gases in a reverse direction through Cyprane vaporizers results in approximately double the output indicated on the vaporizer dial. Although we teach residents to judge anesthetic depth principally from the patient's signs of anesthesia and not from the vaporizer setting, an unintentional doubling of the delivered anesthetic concentration can certainly be hazardous.

Connecting a free-standing vaporizer backwards is easily done and easily overlooked. This approximately doubles the anesthetic output. If portable vaporizers are used in your operating room, special care must be taken to be sure that gases flow through them in the proper direction.

### Table 1. Mean Delivered Anesthetic Concentrations with Vaporizing Gas Flowing in Proper and Reverse Directions

<table>
<thead>
<tr>
<th>Vaporizer and Anesthetic</th>
<th>Dial Setting (Per Cent)</th>
<th>Proper Flow</th>
<th>Reverse Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluotec Mark II (halothane)</td>
<td>0.5</td>
<td>0.60</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.15</td>
<td>2.30</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>1.65</td>
<td>&gt;3.00</td>
</tr>
<tr>
<td>Fluotec Mark III (halothane)</td>
<td>0.5</td>
<td>0.40</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.00</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td>1.70</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2.50</td>
<td>&gt;3.00</td>
</tr>
<tr>
<td>Ethrane (enflurane)</td>
<td>1</td>
<td>0.80</td>
<td>1.65</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1.80</td>
<td>3.60</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>2.75</td>
<td>&gt;4.50</td>
</tr>
</tbody>
</table>

Not knowing what concentrations of anesthetic are vaporized when agent-specific, variable-flow vaporizers are used with gases flowing backwards, and being unable to find the answer in the literature, we measured concentrations of anesthetic delivered from our free-standing vaporizers with gases flowing in the proper and reverse directions.

A Narcotest-M† was used to measure halothane and enflurane concentrations. This anesthetic gas meter has been shown to be accurate within ±0.1 per cent halothane at its full scale deflection of 3 per cent. The calibration of the Narcotest-M was checked with a temperature-monitored Copper Kettle® vaporizer. A table published by Lowe and Hagler was used to derive enflurane concentrations.3

† North American Drager, Telford, Pennsylvania.

### References