Failure of the Agent-Specific Filling Device

To the Editor—The agent-specific filling device keyed filler system is currently in use to prevent accidental filling of an agent-specific vaporizer with the wrong anesthetic agent. This color-coded system is composed of a keyed bottle collar attached securely to the shoulder of the bottle, an adaptor tube, and a vaporizer filler receptacle. The adaptor tube is keyed at both ends so that it will fit only the bottle and the vaporizer for which it was designed.

We recently discovered in the system a potential failure mode which would allow an agent-specific vaporizer to be filled with the wrong agent. When we attempted to place the adaptor tube onto the keyed bottled collar of a newly opened bottle of halothane (manufactured by Halocarbon Laboratories, Inc.), we discovered that the keyed bottle collar had been placed on the bottle upside down. We then attempted to place an enflurane adaptor tube onto the inverted collar and were surprised to find that, since the two collars are mirror images of each other (fig. 1), the enflurane adaptor tube fit onto the defective halothane bottle (fig. 2). Because the adaptor tube did not fit tightly onto the defective halothane bottle, there was a small leak of agent around the collar as well as free flow of agent from the adaptor filler tip. The possibility of using the wrong adaptor tube filler assembly in this situation is made worse by the similarity in color coding between halothane (red) and enflurane (orange).

We propose two changes in the agent-specific filler system to prevent this failure mode. First, the halothane and enflurane collars should be changed so that they are not symmetric reflections of each other. For example, the current isoflurane collar is unrelated to either the halothane or enflurane collars; as a result, an inverted isoflurane collar makes the agent-specific filler system unusable, not misusable.

Our second proposal is to make the actual bottle opening spouts different sizes. Bottles for enflurane and isoflurane (Anaquest) come with the same size spout and thread configuration, and interchangeable caps.

A possible combination of these two proposals would result in a system similar to the diameter index safety system (DISS). Small spouts could be paired with large collars and vice versa, thus producing a system in which it would be impossible to attach the adaptor tube to the wrong bottle regardless of the orientation of the shoulder collar.

The frequency with which this defect occurs is unknown, but was reported in 1984. Changes such as those we propose above, while involving short-term cost to manufacturers and users of volatile anesthetic agents, would be relatively simple to implement and would further improve the safety of the agent-specific keyed filler system.

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REFERENCES


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In Reply—A filling error such as that described by Riegel and Desertspring has never been reported. It is true that if the keyed collar on the halothane bottle should be accidentally installed upside down it would be physically possible to place an enfurane adaptor over the threads of a halothane bottle, but without a threaded connection because of diameter differences. Even in such a situation the practitioner would be made aware of the error by four different warnings: 1) no threaded connection could be made; 2) the mismatch would cause noticeable leakage during filling; 3) the color coding between bottle and filler would not match (enfurane’s color is orange; halothane’s is red); and 4) the bottles are prominently labeled as to content.

Anesthesiology

Capnometer Readings at High Altitude

To the Editor—This letter is to alert those who work at altitudes much above sea level to a potential problem in misinformation generated by carbon dioxide analyzers not properly calibrated for altitude. While evaluating a prototype clinical mass spectrometer (Paradigm, Boulder, CO) in parallel with our Datacomp Multinex 4300 (Datacomp, Paramus, NJ), it became obvious that the Datacomp unit gave consistently high values, even after field service personnel checked the calibration of the device. During moderate hyperventilation, the mass spectrometer showed end-tidal CO₂ values of 31 mmHg, whereas the Multinex 4300 indicated 38 mmHg. At the end of one case the mass spectrometer indicated an end-tidal CO₂ concentration of 48 mmHg, and the Multinex indicated a value of 64 mmHg.

Further investigation revealed that the manufacturer provided no procedure for altitude compensation when converting from per cent values to mmHg. Specifically:

\[ P_{CO_2} \text{ mmHg} = F_{CO_2} \times (P_B - P_{H_2}O) \]

where \( F_{CO_2} = \% \text{ CO}_2 / 100 \). The Multinex 4300 calibration instructions call for a 5% CO₂ calibration gas to be injected while an output voltage is adjusted to a fixed level, subsequently displayed as 38 mmHg, i.e.:

\[ P_{CO_2} \text{ mmHg} = F_{CO_2} \times (760 - 0) \]

The Multinex 4300 measured a series of calibration gases (Scott Medical Products, Plumsteadville, PA) at a barometric pressure of 630 mmHg (dry gases) (table 1). This error is different from, and at our altitude larger than, the problem of correction for water vapor pressure discussed recently by Severinghaus.

Neither the Datacomp unit nor the Paradigm unit corrected for alveolar water vapor, although the Paradigm unit now permits either dry or wet gas data presentation. Severinghaus’s summary of the conventions observed by respiratory physiologists surely is correct, with mmHg being reserved for wet gas readings and per cent reserved for dry gas readings. In addition, he

Table 1. Calibration Gases Measured by the Multinex 4300 at a Barometric Pressure of 630 mmHg

<table>
<thead>
<tr>
<th>Calibration Gas %</th>
<th>Calculated Partial Pressure</th>
<th>Measured Partial Pressure (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0</td>
<td>12.6</td>
<td>14 (2.22)</td>
</tr>
<tr>
<td>3.0</td>
<td>18.9</td>
<td>22 (3.49)</td>
</tr>
<tr>
<td>4.0</td>
<td>25.2</td>
<td>30 (4.76)</td>
</tr>
<tr>
<td>5.0</td>
<td>31.5</td>
<td>38 (6.03)</td>
</tr>
<tr>
<td>6.0</td>
<td>37.8</td>
<td>47 (7.46)</td>
</tr>
<tr>
<td>7.0</td>
<td>44.1</td>
<td>54 (8.57)</td>
</tr>
</tbody>
</table>

is correct that those of us measuring end-tidal CO₂ clinically wish to measure the alveolar (wet gas) partial pressure. Nonetheless, correcting for alveolar water vapor with the somewhat arcane analog-era practice of forcing a measuring instrument to "misread" a dry calibration gas is confusing to many of the clinicians and engineers now concerned with these measurements. There is merit to solving the complex problem of correcting for changes in water vapor content at the time patient data are computed. Clearly, 5% CO₂ in Boulder has a partial pressure of 31.5 mmHg; it is only when the sample has been dried between the alveolus and the measuring instrument that reporting the result as 31.5 mmHg instead of 29.4 mmHg incorrectly estimates the alveolar partial pressure of the gas.

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Even so, we regret any possibility of inversion of the collar, and we have redesigned the process of putting the collar on the bottle, with the use of the keyed system itself to insure proper orientation of the collar.

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