ICU
MANAGEMENT & PRACTICE

# ICU Volume 6 - Issue 2 - Summer 2006 - Product Comparison: Multigas Monitors

## Multiple Medical Gas Monitors, Respired/Aesthetic

#### Introduction

This product comparison covers stand-alone and modular multiple medical gas monitors (MMGMs) that can determine concentrations of aesthetic and respiratory gases (oxygen [O2], nitrous oxide [N2O], carbon dioxide [CO2] and halogenated agents) in the patient breathing circuit during anaesthesia. MMGMs continuously sample and measure inspired and expired (end-tidal) concentrations of respiratory and aesthetic gases during and immediately following aesthetic administration. An overdose of aesthetic agent and/or too little O2 can lead to brain damage and death, while an underdose of agent will result in insufficient anaesthesia.

Some deaths related to anaesthesia use might be preventable with adequate respired and aesthetic gas monitoring in the operating room (OR). During general anaesthesia, the patient's physiologic status must be continuously assessed and trends and sudden changes quickly identified. Gas monitoring provides the anaesthetist with information about the patient's physiologic status, verifies that the appropriate levels of delivered gases are administered, and warns of equipment failures or abnormalities in the gas delivery system. MMGMs display inspired/expired gas concentrations and sound alarms to alert clinical personnel when the concentrations of measured gases and the physiologic parameters fall outside set limits. In most units, the gases are automatically identified and quantified, although some MMGMs require that the user select the halogenated agent being used or that the monitor be equipped with a special option to identify the halogenated agent.

#### Reported Problems

The accumulation of water-vapour condensation or other materials in the sampling chamber can interfere with the accuracy of MMGMs. Some monitors circumvent this problem by trapping condensate before it reaches the chamber, while others use special tubing (Nafion) and hydrophobic filters to prevent water vapour fromaffecting monitor performance; however, some manufacturers still recommend periodically cleaning the chamber, particularly to prevent the accumulation of secretions or other foreign matter.

The presence of nitrogen (N2) in the inspired gases indicates that air is being aspirated into the breathing circuit, thereby diluting the delivered gas concentration. Although most MMGMs do not monitor N2 concentration, such leaks can often be identified from changing O 2 and CO2 trends.

For MMGMs that cannot identify halogenated agents, the user must set the agent selection control according to the halogenated aesthetic being used. Clinical personnel must be relied on to fill the vaporizers with the proper agent (a keyed filling system will help avoid errors) and to connect the breathing circuit correctly to preclude accidental use of the wrong or multiple anaesthetics.

The presence of alcohol or other organic vapour in the room, in a sample line, or in a patient's breath can cause inaccurate concentration readings on monitors that cannot distinguish these compounds from aesthetic agents. MMGMs that both identify and quantify halogenated agents can eliminate interference from these compounds because these monitors measure concentrations of halogenated agents at a wavelength where organic vapours do not have a peak in the infrared absorption spectrum.

#### Purchase Considerations

#### ECRI Recommendations

The MMGM should continuously sample and measure inspired and expired concentrations of respiratory and aesthetic gases during and immediately following aesthetic administration. The device may also include monitoring of other variables such as oxygen saturation (SpO2), airway pressure, and volume monitoring.

The MMGM should display inspired and expired gas concentrations of CO 2 and halogenated agent, inspired (or mean) concentrations of O 2 and N2O, and respiration rate. Monitors should accurately measure gas concentration over the range that is encountered clinically and should compensate for the interference effects between gas constituents. The range that a monitor should be able to measure and the accuracy that it should achieve for each of the analyzed gases should be as follows:

• 0-6% halothane with an accuracy of 0.25 volume %.

• 0-6% enflurane with an accuracy of 0.25 volume %.

• 0-6% isoflurane with an accuracy of 0.25 volume %.

• 0-10% sevoflurane with an accuracy of 0.25 volume %.

• 0-20% desflurane with an accuracy of 0.25 volume %.

• 0-80% nitrous oxide with an accuracy of 10% of reading or 5volume %, whichever is greater.

• 0-10%carbon dioxide with an accuracy of 10% of reading or 0.4 volume %, whichever is greater.

• 0-100% oxygen with an accuracy of 5% of reading or 2 volume%, whichever is greater.

Interference with measurements caused by the presence of water vapour, aspirated fluid, or pressure in the breathing circuit should be eliminated or automatically compensated for by the MMGM.

The MMGM should remain zeroed and calibrated for at least six months. Measurements should remain accurate over commonly used ventilation rates (i.e., 25 b/min for adults and up to 60 b/min if the monitor is intended for neonatal or paediatric applications.) The rise time for O2 measurements should be less than 20 seconds.

Alarm limits should be easy to review and set. The anaesthetist should be able to view all alarm limits and gas concentration displays simultaneously while reviewing and setting alarm limits. Alarms should be available for all parameters that the MMGM monitors. The unit should alarm to indicate an occluded sampling line or a system failure. For safe, effective monitoring, units should meet several minimumcritical alarmcriteria:

• The apnea alarm (associated with CO2 monitoring) and the low O2 alarm limit are critical in all situations and should be impossible to disable.

• The low haemoglobin SpO2 alarm limit (associated with pulse oximetry) is also critical; however, this alarm limit may be turned off, provided a visual indicator warns of this condition.

• For both low O2 and low SpO2, it should not be possible to lower alarm limits to values that are not clinically useful (minimum settings of 18% and 50%, respectively).

•Monitors should allow flexibility in setting alarm limits and help minimize the use of inappropriate settings, and the alarm limits should be easy to review on a single screen.

If the displayed CO2 concentration is changed between mm Hg and percent CO 2, the actual alarm-limit setting should not be altered, and preferably, the alarm limit will be converted into the new units. It should not be possible to indefinitely silence the apnoea alarm

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Agent monitoring should activate automatically when the unit is turned on. It is acceptable, however, for the unit to require that agent be selected before monitoring begins, provided that the unit warns the user when agent is detected but has not been selected. MMGMs equipped with pulse oximetry should have a probe failure/disconnect alarm and audible alarms for low and high SpO2 and low and high pulse rate. The monitor should indicate when SpO2 and pulse rate readings are likely to be inaccurate due to a weak pulse.

The MMGM should display the CO2 waveform. It is preferable that the unit allow the user to select at least two additional graphical displays (e.g., waveforms and trends).

Exhaust gas from the MMGM must be returned to the patient's breathing circuit or scavenged. Performance should not be affected by attachment to a scavenger. When gas is to be scavenged, an easy-to-access port to which the sampling tube cannot be connected should be provided with the monitor. Manufacturers should provide tubing (of a smaller diameter than the breathing circuit) with the appropriate fittings to connect the exhaust port to the expiratory breathing circuit (22 mm tee) or a scavenger (19 mm tee).

**Other Considerations**

MMGMs are produced as either a configured unit or a modular part of a physiologic monitoring system. A facility should consider the status of its present physiologic monitoring system before purchasing an MMGM. A modular MMGM may allow all information and alarms to be integrated into one display. MMGMs can also be integrated into anaesthesia delivery units.

The variety of MMGM configurations available permits a facility to add modules to expand the capabilities of its monitoring equipment. For example, if a hospital has pulse oximeters, it can purchase units without the pulse oximeter option. If a facility is planning to replace its current aesthetic delivery equipment, it may want to consider an anaesthesia system with optional modules for combined CO2, N2O and agent monitoring and/or for pulse oximetry.

To achieve the degree of accuracy and performance reliability necessary for aesthetic monitoring, MMGMs require careful maintenance by qualified biomedical engineering personnel. Users may want to check the availability of service and the repair turnaround time before selecting multigas monitors for their facilities.

#### Cost Containment

Whitcher et al. reviewed studies of related-related incidents and determined the cost- benefit ratio of OR monitors used to detect specific problems (Whitcher et al. 1988). The authors concluded that the savings in malpractice insurance alone would cover the cost of equipping each OR with monitors that measure each variable recommended by the American Society of Anesthesiologists.

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