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Title : HAZARDS ASSOCIATED WITH THE USE OF DISCONNECT MONITORS

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Introduction. Despite significant improvements in the safety of anesthetic machines and ancillary equipment in recent years, breathing-circuit disconnections remain a frequent and potentially serious hazard. In a study of 359 preventable anesthetic incidents, Cooper et al reported that disconnection in the breathing circuit was the most frequent problem, and half of the breathing-circuit disconnections which occurred during mechanical ventilation resulted in hypoxia, cardiac arrest or death.[1] Increasing recognition of the hazards associated with breathing-circuit disconnections has led to recommendations that anesthesia ventilators be used only in conjunction with low-pressure or patient disconnect alarms.[2]

Characteristics of Disconnect Monitors. The two types of disconnect monitors which are widely available for use with anesthetic ventilators function as follows: if no pressure above a specific threshold is detected at the sensing location for a period of approximately 15 seconds, an alarm is activated. One fluidic monitor (Ohio Medical Products) has a pressure threshold which is internally set at approximately 8 cmH_2O and has an audible alarm which is automatically cancelled when the required pressure is restored. A second electronic monitor (North American Drager) has a pressure threshold which can be set at 5, 12.5 or 25 cmH_2O and has audible and visual alarms which are automatically cancelled when the sensed pressure meets or exceeds the pre-set threshold. Other types of disconnect monitors, such as one which accommodates PEEP by sensing a differential pressure of 8 cmH_2O rather than absolute pressure, are also available but are not used widely in anesthesia. Two recent incidents at the Vancouver General Hospital suggest that the currently available types of low-pressure or disconnect pressure monitors (DPM's) may not reliably indicate some commonly occurring types of breathing-circuit disconnections.

Review of Incidents. In one serious incident, a patient was connected to a Drager anesthetic gas machine and ventilator, complete with a DPM which had been pre-set to a pressure threshold of 5 cmH_2O and properly checked prior to use. Approximately fifty minutes after induction of anesthesia for a carotid endarterectomy, the patient went into bradycardia and then cardiac arrest. When the drapes were removed to begin external cardiac message it was noted that there was a disconnection at the endotracheal tube, and the "Y" connector was lying against the patient's pillow. Although cardiac function was restored at the time, the patient died six days later. The DPM did not alarm prior to the arrest. A retrospective simulation of the incident was conducted and the pressure waveform shown in Fig. 1a was recorded and compared to the normal waveform (Fig. 1b). Fig. 1a indicates that the Drager DPM at a setting of 5.0 cmH_2O would not detect the disconnection (although it may have done so at settings of 12.5 or 25 cmH_2O). Moreover, other types of DPM's, such as those with fixed thresholds at 8 cmH_2O, would not have detected the disconnection. Simulations of similar conditions, such as disconnections with partially kinked hoses and partially occluded connector apertures, resulted in similar pressure waveforms which would prevent the commercially available DPM's from alarming.

A second incident was detected before serious injury resulted. A patient was connected via a Bain circuit to a Drager anesthetic machine with ventilator and DPM for a neurosurgical procedure. Investigation of an incompletely descending bellows revealed that the fresh-gas tubing from the common gas outlet had become pinched in a drawer of the anesthetic machine. After that problem was corrected, ECG changes and dark blood still suggested inadequate ventilation. The circuit pressure gauge indicated rising and falling pressure and the DPM did not alarm. However, a check of the anesthetic machine revealed a disconnection at the vaporizer, likely due to a pressure increase caused by the pinched tubing. After this problem was corrected, the procedure continued uneventfully. Subsequent tests indicated that disconnections at the vaporizer would not be detected by any of the currently available DPM's: in the incident, the maximum pressure decreased from 20 cmH_2O to only 16 cmH_2O after the disconnection (Fig. 1c), apparently because of flow resistance in the path between the Bain adapter and vaporizer.

Discussion. Because currently available DPM's do not reliably warn of some commonly occurring types of breathing-circuit disconnections, the development of a microprocessor-based disconnect monitor has been undertaken.[3] This device implements a simple, self-learning pattern-recognition algorithm which "remembers" the normal pressure in the breathing circuit and automatically detects significant abnormalities in the ongoing pressure pattern.

References

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2. Emergency Care Research Institute, Anesthesia ventilators, Health Devices 8: 151-164, 1979.
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FIGURE 1. BREATHING CIRCUIT PRESSURES