LINKING MASS SPECTROMETERS TO PROVIDE CONTINUING MONITORING DURING SYSTEM FAILURE

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ABSTRACT. Although multipatient monitoring with a time-shared mass spectrometer provides considerable cost advantages, failure of one component in a shared system can disrupt gas monitoring at all sites. We describe a simple method for linking two central mass spectrometer systems to provide continual monitoring during failure of one unit, without the need for time-consuming reconfiguration of individual patient sample line and display connections.


The mass spectrometer has proven to be a versatile monitor for anesthetic and respiratory gas analysis. Despite the large capital equipment and personnel expenses to install and maintain a mass spectrometer, multipatient monitoring with a single, centrally located mass spectrometer results in relatively low cost per patient. Nevertheless, failure of one component in a shared system can deprive the entire operating room suite of gas monitoring while repairs are made. We report the physical linking of two central mass spectrometers to provide continual monitoring during failure of one unit.

METHODS AND MATERIALS

Two time-shared mass spectrometer (TSMS) systems provide gas monitoring for 30 operating rooms at Brigham and Women’s Hospital (Boston, MA). Each TSMS consists of a Marquette medical gas analyzer (MGA) mass spectrometer (model 1100, Marquette Gas Analysis Corp, St. Louis, MO) with its corresponding inlet select unit (ISU) (model 1700). Each TSMS system is configured as shown in Figure 1. Nylon capillary gas sampling tubing and electronic signal cable connect each of 15 monitoring sites (i.e., operating rooms) to the ISU. A pressure-regulated vacuum pump (−25 in Hg, gauge) in the ISU aspirates continuous gas flows of approximately 240 mL/min from each site, except the site selected for MGA analysis, which is aspirated by the roughing pump of the MGA. A computer directs the rotary selector valve to sample gas sequentially from active sites. A monitoring site becomes active when the anesthesiologist at the site pushes the “on” button of the keypad of the patient display unit (PDU). The site remains active until the anesthesiologist pushes the “off” button of the PDU. An audible, nondefeatable apnea alarm reminds anesthesiologists to push the “off” button when patient monitoring is terminated between cases. Dwell time has been adjusted to be the lesser of
two breaths or 18 seconds. The communication controller board transmits information from the MGA to the appropriate PDU. A dedicated infrared (IR) capnometer (Lifewatch Plus, Marquette) in each operating room provides a continuous qualitative or quantitative capnogram.

Operation of the system during failure of one mass spectrometer (MGA I) is illustrated in Figure 2. The numbers in the figure correspond to the following steps: (1) the power and computer bus cables from communication controller board I are connected via extender cables to the corresponding board II, (2) the power and communication cables from rotary selector valve I are attached via extender cables to power supply and computer in ISU II, (3) the output port of valve I is attached to an inlet port of valve II, (4) dip socket switches on MGA interface board II are checked to ensure that they are set to indicate two active valves, and (5) suction is changed from the continuous vacuum pump I to wall suction (not shown in Fig 2).*

In the event of failure of MGA II rather than MGA I, the cable connecting ISU II to MGA II is disconnected at MGA II and connected to MGA I (Fig 2).

RESULTS

Failure of one MGA was simulated during performance of scheduled preventive maintenance. A clinical engineer (W.R.E.), working alone, was able to make the connections linking two ISUs, as described above, in 29 minutes. Following the planned maintenance, less than 16 minutes were needed to undo the linkage, functionally separating two TSMS systems.

DISCUSSION

For multipatient monitoring, the cost advantages of a TSMS system can be considerable. Including costs for capital purchase, repair parts, service, and reusable supplies, Frazier and Odom calculated that their 16-room TSMS system cost $2.34 per case over approximately 63,000 cases during the first 7 years of use [1]. For comparison, using 16 dedicated multigas analyzers at $14,000.00 each, the capital cost alone (i.e., excluding parts, service, and supplies) would be $3.56 for the same number of cases. Furthermore, service support for multiple stand-alone monitors is likely to be more costly than for a single, albeit more complex, TSMS system.

Partially offsetting the cost advantages of a TSMS system is the potential loss of gas monitoring for an entire operating room suite during system failure. At the Brigham and Women's Hospital, prior to development of the linkage arrangement described above, we had experienced 5 service outages resulting in approximately 9 days without mass spectrometry over 3 years. During each failure, dedicated IR capnometers maintained qualitative capnography (i.e., CO₂ waveform

* A more detailed description of the actual connections is available from the authors.