DATE:

TITLE: EVALUATION OF OXYGEN MONITORS FOR CLINICAL USE

AUTHORS: D. R. Westenskow, Ph.D., W. S. Jordan, M.D., R. B. Jordan and S. T. Gillmor

AFFILIATION: Department of Anesthesiology, University of Utah College of Medicine, Salt Lake City, Utah 84132

Introduction. Monitoring of the oxygen concentration within the patient breathing circuit during anesthesia is becoming increasingly more common. Polarographic and fuel cell type oxygen sensors are generally placed directly in the anesthesia circuit and relied on to warn off unsuspected or dangerous levels of oxygen.[1] This investigation reports the accuracy and stability of these monitors when they are used in gases containing clinically used concentrations of halothane, nitrous oxide and water vapor.

Methods. Five oxygen cells were obtained from each of four manufacturers: Beckman Instruments, Critikon, Instrumentation Laboratory and Teledyne. The oxygen cells were used with the monitoring electronics supplied by each manufacturer. Following a one hour warm-up period, each of the 20 oxygen cells was calibrated using a two point calibration with pure nitrogen and pure oxygen. The cells were then exposed to a 5 liter/min flow of air while monitoring the output continuously on a strip chart recorder. At 2, 4 and 6 hours the cells were exposed again to pure nitrogen and pure oxygen and their outputs recorded. This data gave a measure of the oxygen cell stability with time.

The 20 cells were next exposed to 3% halothane in air for 6 hours. The cell output was measured at 2, 4 and 6 hours with the cell in pure nitrogen and pure oxygen. This part of the study defined the long term effect of halothane on the oxygen cell performance.

The cells were finally placed in a 5 liter/min flow of water saturated air for 6 hours (100% relative humidity at 34° C). At 2, 4 and 6 hours the cells were placed in dry nitrogen and oxygen to measure the effects of water condensation and membrane flooding on the cell's accuracy.

The temperature coefficient, response time and nitrous oxide effect were measured for each of the 20 oxygen cells.

Results. There was no significant drift in oxygen sensor output during the one hour warm-up period for any of the cells tested. Following 6 hours exposure to 3% halothane there was no significant change in sensor performance. Following 2 hours of exposure to water saturated air the Beckman sensors read on the average 20% low. The recessed membrane of the Beckman sensor was quickly covered with condensed water causing a considerable diffusion gradient and a fall in sensor output. One Critikon sensor failed following exposure to high humidity as water accumulated in the connecting cable to the sensor monitor. There was no significant water vapor effect on the other 14 oxygen cells.

The temperature coefficients for the Beckman, Critikon, Teledyne and IL sensors were respectively 0, +0.27, -1.1 and -0.43% change in reading/°C. The average oxygen readings when placed in 100% N_2O were 0.0, +0.04, -0.14 and +0.1% oxygen. Response times were 10.1, 5.1, 20.6 and 2.9 seconds, respectively.

Discussion. This study was designed to evaluate the performance of several commercially supplied oxygen monitors. The experimental methods simulated conditions found during operating room use with 6 hours of continuous use in gases containing halothane, nitrous oxide and 100% relative humidity. We found all sensors to be extremely stable showing no significant drift over a 6 hour period when exposed to air or halothane. Polarizing voltages for the polarographic sensors are chosen which avoid any halothane effect.[2, 3] The temperature and N_2O effects were small enough to have little clinical significance.

Water droplets formed on the membranes of all sensors during exposure to high humidity. This same condensation is seen during clinical use of these sensors. Water condensation did not aversely effect the performance of the oxygen sensors with the exception of the Beckman unit. The geometry of the Beckman sensor makes the reason for this effect obvious.

After presenting data showing adequate sensor performance, one wonders why many clinicians distrust oxygen monitors. Conditions where an oxygen monitor may be deceiving occur when 1) the sensor is placed in the expiratory gas where the O_2 reading is influenced by CO_2 and water vapor excretion, 2) the sensor is calibrated before the sensor has time to warm-up sufficiently, 3) a slow response time is not considered during calibration or 4) the temperature coefficient is not considered. The monitor may actually be incorrect if 1) the cell lifetime has been exceeded, 2) the membrane has been punctured or 3) the battery supply is low. The oxygen monitors tested in this study performed well under clinical conditions but they must be used with logic and caution.

References.

1. Schneider AJL, Kreul JF, Zollinger RM Jr: Patient monitoring in the operating room - An anesthetist's viewpoint. Med Instru 10:105-109, 1976

2. Dent JG, Netter KJ: Errors in oxygen tension measurements caused by halothane. Br J Anaesth 48: 195-197, 1976

3. Severinghaus JW, Weiskopf RB, Nishimura M, et al: Oxygen electrode errors due to polarographic reduction of halothane. J Appl Physiol 31:640-642, 1971