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Title : A TECHNIQUE FOR FAST-RESPONSE ANAESTHETIC GAS MONITORING

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Introduction. The safe and efficient administration of inhalation anaesthetic agents is of major clinical concern. The true anaesthetic exposure of the patient is determined by a number of factors, most of them difficult to control accurately. Thus the inspired gas concentration will be affected by the vaporizer performance characteristics as well as the degree of rebreathing employed. In addition the dynamic wash-in/wash-out process will in general result in alveolar concentrations that differ from the inspired value. Therefore breath-by-breath monitoring of the anaesthetic concentration (especially the end tidal value) and the uptake is of considerable value when evaluating and controlling the progress of the anaesthetic procedure. The comprehensive literature available on the MAC (minimum alveolar concentration) concept can then be used as guidance to facilitate safe and rapid induction and to better predict and control the time of recovery.[1]

Method. A simple, but highly sensitive method for measuring the concentration of most inhalation anaesthetics breath-by-breath has been developed to meet the requirements of routine clinical use as described above. An instrument has been built that detects halothane, enflurane, methoxyflurane, isoflurane, trichlorethylene or fluroxene. The function of the device is based on the fact that the resonance frequency of a highly stable coated quartz crystal oscillator may change as a result of an interaction between the coating and a surrounding gas.[2] An electric signal proportional to the gas concentration can be obtained in this way. With the crystal mounted in a compact measuring head (weight ~ 160 g, volume ~ 13 ml and resistance to flow ~ 1 cm H_2O at 1 l/s) the concentration can be monitored anywhere in the gas circuit. The head is connected to an electronic display unit that provides concentration limit alarms and recording facilities.

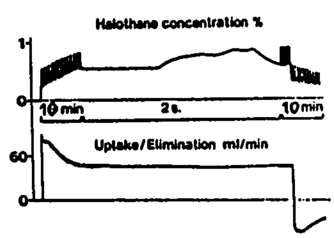
Results. The sensitivity of the method is typically 0.02% halothane and the inherent response time is about 0.1 s. The long term (24 h) stability is 0.1 % after a warm up period of 5 minutes. There is no interference from O_2, CO_2, N_2 or N_2O. Water vapor produces a small artifact corresponding to about 0.15% halothane for a gas with 100% relative humidity at 25°C. Certain organic gases such as aceton and alcohol can also be detected. The instrument cannot differentiate between the various detectable gases so the gas present must be identified in advance and a gas selector knob set accordingly for correct measurements.

Discussion. The instrument has been used to measure the halothane and enflurane concentration at various points in a partial rebreathing system. Simultaneously, by using two additional measuring heads, the anaesthetic uptake/elimination was recorded. This was done by placing one probe on the vaporizer output and one probe after a mixing chamber that was connected to the outlet of the exhaust valve. The difference between the mean concentration delivered into and the mean concentration removed from the breathing system multiplied by the fresh gas flow yields the uptake or the elimination value.

Figure 1 below shows the concentration at the Y-piece and simultaneously recorded uptake/elmination curves. One breath is shown time resolved to demonstrate the rapid response of the system. There is a time delay of ~ 30 s for the uptake data primarily due to the time constant of the breathing circuit and the mixing box.

A comparison between the present instrument and an optical refractometer has also been made. The data was collected in the course of callibration of halothane vaporizers in the concentration range 0.4-4.5%. For 38 measurements the average ratio of the two instrument readings was 0.98 with a SD of 0.008.

References
1. de Jong R.H., and Eger E. J. II: MAC expanded AD_{50} and AD_{95}-values of common inhalation anesthetics in man, Anesthesiology 42, 384 1975,
2. Hlavay J., Guilbault G.G.: Detection of hydrogen chloride gas in ambient air with a coated piezoelectric Quartz Crystal, Analytical Chemistry 50, 965-967, 1978.



Halothane concentration measured at the Y-piece of an anaesthetic breathing circuit with partial rebreathing during induction and recovery (upper drawing). Uptake/elimination during the same period (lower drawing). Note the expanded time scale that shows concentration variations during a single breath.