

**TITLE:** EVALUATION OF TWO NEWLY DEVELOPED ANESTHETIC AGENT MONITORS: BRÜEL & KJÆR ANESTHETIC AGENT MONITOR 1304 (BK 1304) AND DATEX CAPNOMAC ULTIMA (ULTIMA).

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The demand for closer monitoring during anesthesia, has resulted in the availability of several monitoring devices. We have compared the actual performances of two new anesthetic agent monitors, with almost equal technical specifications.

Both devices monitor the in- and expired fractions of: O<sub>2</sub>, CO<sub>2</sub>, N<sub>2</sub>O and anesthetic agent (AA) (isoflurane / enflurane / halothane). The performance of the built-in pulse oximeter is not part of the presentation. The measuring principle differs between the monitors; BK 1304 is using photoacoustic spectroscopy, whereas ULTIMA is using infrared absorption spectrophotometry. Neither monitor is able - for the time being - to detect which AA is being delivered, this must be defined before anesthesia.

The aim of this investigation, was to test the following parameters: - linearity (precision) of monitored value of AA, O<sub>2</sub>, CO<sub>2</sub> and N<sub>2</sub>O, - rise (response) time of each of the above mentioned gases, - interference of the other gases on AA, - consequences if the delivered AA differs from the one being monitored, and if a mixture of AA is being delivered, - the effects of variation of airway pressure, water vapor and alcohol in the expired air.

Based upon the laws of ideal and real gases, a spectrum of AA mixtures was produced, knowing the molecular weights and compressibility factors of the specific agents; using a precision balance and following vaporization in a bottle with known volume. Mixtures of O<sub>2</sub>, CO<sub>2</sub> and N<sub>2</sub>O were produced, using pure gases in precision syringes.

Reproductability tests showed the precision to be  $\pm 0.01$  VOL%.

Concerning the linearity-curves (monitored value versus actual) for O<sub>2</sub>, CO<sub>2</sub> and N<sub>2</sub>O, the fits were ideal, whereas both monitors showed some underprediction of the AA, 2-4% rel. for BK 1304 and 8-10% rel. for ULTIMA. Using a set-up adapted to the clinical situation, the time-constant for all gases was found higher than expected from the stated response times, thus leading to increasing inaccuracy when the respiratory rate exceeds 30 min<sup>-1</sup> for ULTIMA, and 40 min<sup>-1</sup> for BK 1304. No interference of other gases on AA was found. The consequences of difference between used and monitored AA were found of little clinical importance with BK 1304 (up to 30% rel.), whereas ULTIMA showed greater over- or under-prediction (up to 600% rel.) (Table 1). The same applies to the consequences of delivery of mixed AA. Neither monitor was affected by variation in airway pressure, water vapor or alcohol in the expired air. We conclude that the precision of both monitors is acceptable for clinical use, but - using the ULTIMA - one should be aware of the under/over-estimation seen when the used AA differs from the monitored, or a mixture of AA is delivered.

Table 1.

Delivered AA Versus Monitored AA.

DELIVERED AA Vol%	BK 1304 Vol%	ULTIMA Vol%
ISO 0.95	ISO 0.93 ENF 0.75 HAL 0.90	ISO 1.0 ENF 1.2 HAL 8.0
ENF 0.98	ISO 1.25 ENF 0.95 HAL 1.25	ISO 1.0 ENF 1.0 HAL 4.9
HAL 0.83	ISO 0.85 ENF 0.85 HAL 0.80	ISO 0.1 ENF 0.2 HAL 0.8

## A539

**TITLE:** ANESTHETISTS CANNOT IDENTIFY AUDIBLE ALARMS

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**Introduction.** When an alarm sounds in the OR, it must be identified immediately. Many machines in the OR generate alarms; the inability to identify an alarm can delay or prevent appropriate action. This study was performed to determine whether current alarms are distinguishable by sound and to identify factors which increase alarm recognition.

**Methods.** The Human Subjects Research Committee at our institution approved the study. Nineteen alarm sounds from fifteen machines in our ORs were recorded without distortion. The sounds were replayed at normal intensity to 44 clinicians from the anesthesia department. These included 12 active clinical faculty, 23 residents, and 9 CRNAs. The alarms were played in random order and each alarm was played at two separate times. From a list of monitors, the anesthetists were asked to choose the one which produced the alarm. Later, the clinician rated each alarm's importance and the frequency that he heard it in the clinical situation. The recordings were analyzed to determine the complexity of each sound and to group sounds which were similar. This was done by a speech pathologist who was unaware

of the results and unfamiliar with the alarms.

**Results.** A total of 1672 responses were collected. Clinicians correctly identified alarms only 34% of the time. The recognition rate was higher for alarms which were more frequently heard. Alarms which were rated as more important were less likely to be correctly identified. The best recognized alarm was correctly identified 92% of the time while the least recognized alarm was correctly identified only 1% of the time. Sound complexity did not affect recognition rate. However, there was a positive correlation between alarm volume and recognition rate. Of the mistaken identities, 26% could be retrospectively attributed to similarities between alarm sounds and 20% to similarities between alarm functions.

**Conclusions.** This study shows that anesthetists cannot identify familiar audible alarms by sound characteristics alone. In the operating room there are additional visual indicators and auditory spatial cues which aid in identification. Alarm sounds which are distinct for each monitor may not help the clinician and it may be appropriate to reevaluate the concept that each monitor needs a distinctive sounding alarm. Since anesthetists seem to mentally group alarms by function, it may be appropriate to assign similar sounds to alarms with similar functions. Infrequently heard alarms are more difficult to identify; it may be helpful to code alarm sounds so that their meaning can be deduced from their pattern.