Title: TOWARDS AN AUTOMATED ANALYSIS OF CAPNOGRAMS

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Introduction: Respiratory CO₂ monitoring during anesthesia by the use of infra-red analyzers or mass-spectroscopy is increasing in popularity. However, since most abnormalities stay within usual level-limits, a continuous monitoring of capnogram-waveforms is highly desirable. This is usually done by the anesthesiologist by regular visual checks. The purpose of this study was to develop a computer program to help the analysis of CO₂ waveforms and hence speed up the detection of abnormal capnograms or machine errors.

Methods: The CO₂ waveform was the only input information considered in the present study.

1) Capnograms were collected with a Perkin Elmer Advantage mass spectrometer. They were recorded in digital format on floppy-disks, with an average of 200 samples per respiratory cycle. Floppy-disks were then entered into the computer (IBM-XT with mathematic coprocessor), and then analyzed off-line. Color-coded curves were then plotted with a HP 7440 X-Y plotter. The program source was written in assembler and C-language.

2) Main decision-making rules were (see fig 1):
- minimal CO₂ phases located on a recorded CO₂ curve (A-B). They were considered as insufflation phases, or being part of them, since the small A-B segment matches the clearance time of anatomical dead space at the onset of expiration. Going backwards, the maximum CO₂ (point D) before the previous A-B phase was determined. It was considered as the end-tidal CO₂, and the insufflation phase was supposed to start from there. At this stage, respiratory frequency (RF), end-tidal CO₂, minimal inspired CO₂, and I/E ratio (or at least a minimum value of it) were computed.

Fig 1: analysis of CO₂ waveforms (see text).
- Two regression lines are then computed to detect the expiratory plateau (if present) and appreciate pulmonary inhomogeneity (see fig 1).

Discussion: This program performs a better discrimination of abnormal capnograms and machine errors than the level-triggering method which is now used: it should be considered as a first step to enhance present CO₂ monitoring techniques. Its overall performance does not compete with an anesthesiologist continuously looking at the display, which is ideal but unpractical. This program tries to fill this gap, and should provide early warning when implemented in real time on a faster computer. The most desirable improvement would be to add a flow or volume signal to enhance discrimination between possible diagnoses.

References: