

Title : APPLICATION OF COMPUTER TECHNOLOGY TO INTRA-OPERATIVE PATIENT MONITORING

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Introduction. There have been many attempts to improve the gathering, display, and recording of physiological data by employing computerized automation.¹⁻⁶ However, there is as yet no generalized clinical implementation of computer technology in the O.R. We have undertaken an informal but intensive investigation of the reasons for this apparent incompatibility between computer technology and the operating room environment. Based on a distillation of our analyses and the experiences of other investigators, we have prepared a set of guidelines which, if followed, should result in a generalized introduction of computer technology into the monitoring of the intra-operative patient. In addition, we used the guidelines to design and construct a computer based monitoring system for use in operating rooms.

Methods. Anesthesiologists and anesthesia residents who have had experience using our PDP 11/40 based in O.R. facility were interviewed. They were asked to describe their expectations, disappointments, and other reactions. Reports in the literature describing experience with other systems were reviewed, and personnel familiar with these other systems were consulted. Recent advances in computer technology were investigated with special emphasis on advances in CRT graphics displays, high density erasable programmable read-only memory, high density floppy disc memory, and printer-plotters.

Results. The major findings of this survey resulted in the following guidelines, which are listed in order of decreasing importance.

1. The interactions between the Anesthesiologist and Computerized Monitoring System (CMS) must be of minimal complexity.
2. The CMS should not add to the Anesthesiologist's work load for routine procedures.
3. The CMS should present both real time phasic and digital values, as well as trends.
4. The CMS should have single patient emphasis.
5. The CMS should afford increased reliability and safety.
6. The CMS should afford expanded display and processing capabilities.
7. The CMS should be capable of presenting additional data when more complex monitoring is indicated.
8. The CMS should produce a permanent record of the anesthetic which replaces the current manually produced anesthesia record.
9. The CMS should be portable.

Discussion. We have designed an LSI-11 microprocessor based monitoring system to meet the above guidelines. Five pressures or other parameters are digitally processed and presented as real-time phasic traces and digital values on a high quality vector graphics display. Digital values for time,

two temperatures, and heart rate are also displayed. Calibration is accomplished automatically under microprocessor control. Both short (five minute) and long (up to eight hour) trends can also be displayed. All data is stored and can be recalled easily. Both real-time physiological alarms and trend-based predictive physiological alarms are provided. A permanent record is produced by a printer-plotter which requires no user attendance. Dramatically expanded memory and computational capability are provided by user selected Application Modules. Each Application Module provides all necessary hardware and software for the performance of a sophisticated monitoring task, such as determination of thermodilution cardiac output, compressed spectral array analysis of EEG, ECG arrhythmia analysis, intra-operative spirometric analysis, analysis of pulmonary artery wedge pressure as a function of airway pressure, computation of endocardial viability ratio, or real-time computation of systolic time intervals. A highly simplified, dedicated keyboard and sophisticated prompter display provide ease of interaction between the CMS and anesthesiologist. Reliability of the CMS is enhanced by self-diagnostic and corrective procedures, and sophisticated alarm and warning systems. The advantages expected to accrue from this automation include: increased reliability in the performance of repetitive or continuous monitoring tasks, dramatically expanded computational and memory capability, improved data display capabilities, and the assumption of record keeping functions.

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