AUTOMATED CHARTING OF PHYSIOLOGICAL VARIABLES IN ANESTHESIA: A QUANTITATIVE COMPARISON OF AUTOMATED VERSUS HANDWRITTEN ANESTHESIA RECORDS

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Abstract. Eight physiological variables—tidal volume, breathing rate, end-tidal carbon dioxide fraction, oxygen fraction in the anesthetic circuit, oxygen saturation by pulse oximetry, systolic and diastolic blood pressure, and heart rate—recorded on-line by a commercially available automated system were compared with the same variables recorded on handwritten anesthesia records. We quantified the differences between the automated and handwritten records generated from the same 30 patients (2,412 minutes of general anesthesia for elective eye surgical procedures). Considering the design of the study, we claim that the differences between both records were caused by the incompleteness or inaccuracy of the handwritten records, except in two instances. The amounts of missing or erroneous data for these eight physiological variables were expressed as fraction ("error fractions") of the time being recorded, designated $E_{m}$ and $E_{e}$, respectively. For the first five variables the $E_{m}$ on the handwritten records ranged between 0.23 and 0.31, and the $E_{e}$ ranged between 0.01 and 0.06. For the last three variables the $E_{m}$ range was 0.08 to 0.13, and the $E_{e}$ range was 0.05 to 0.11. Most of these missing or erroneous data occurred during the period of induction (first 15 minutes) and at the end of the case (last 10 minutes). The $E_{m}$ and $E_{e}$ during induction had increased to 0.62 and 0.26, respectively, and to 0.76 and 0.06, respectively, at the end of the case. Erroneous data were observed on the automated records for the tidal volume during induction ($E_{e} = 0.0044$) and for the oxygen fraction during maintenance ($E_{e} = 0.0024$). The effect of averaging by the recordkeeper is discussed. The results of this study indicate the clinical relevance of automated record keeping.


While performing a complex array of tasks, the anesthesiologist is also responsible for maintaining an anesthetic record. This record provides valuable reference data for assessing considered intervening actions and is also a medical and legal requirement. Especially during busy anesthetic periods, record keeping has received a low priority compared with direct patient care. Thus, a problem area may exist because the anesthesiologist has to take care of the patient and at the same time has to add important information to a chart. Advances in technology have made new instruments available to free the hands of the anesthesiologist. Mechanical control of ventilation has replaced manual bag squeezing during long procedures, and the noninvasive automatic blood pressure (NIBP) monitor has already found widespread acceptance in replacing intermittent manual sphygmomanometry. Further automation of the tasks of the anesthesiologist seems to be a line of development for the future.

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Record keeping has been done by hand for almost a century [1]. Obvious benefits of automated record keeping have been claimed, and those recently outlined by Smith [2], include: (1) more accurate data recording, (2) a decreased need for manual charting during crises or other busy periods of anesthetic care, (3) a centralized display on which all data, current and trended, are available on one common screen or other display, and (4) a legible printed record at the end of the case. However, the proposed benefits have to be balanced against possible disadvantages of automated record keeping [3]. These include: (1) less awareness of the time course and detail of anesthetic events, and (2) removal of the physician from the closed loop control of the anesthetic.

Although some of the proposed benefits have been substantiated [4], factual data are scarce and apply only to prototype systems developed in individual institutions. A commercially available automated record keeper, the Ohmeda automated anesthesia record keeper (AARK) integrated into the Modulus II anesthesia system, was used for the present study. This study was designed to compare handwritten records produced at our hospital during clinical practice with computerized records of the same cases. The investigation was limited to the values of those physiological variables that are automatically acquired, displayed, and charted by the AARK.

**METHODS AND MATERIALS**

Thirty patients admitted to our hospital for elective eye surgical procedures were included in the study. General anesthesia was administered by three staff members or six senior residents under supervision. For each patient, two anesthetic records were made. One was the standard handwritten record as used in our hospital; the other was the record prepared by the AARK.

**Equipment**

The AARK has three components: (1) a soft key touchpanel combining the functions of computer-human interface and central display, (2) a central processing unit (CPU), and (3) a printer producing the automated record. All three components are integrated into the structure of the anesthesia system (Ohmeda Modulus II).

The AARK is accessed by touching notated areas on the touchpanel mounted on the absorber post. Touching a specific notation is recognized by the microprocessor, and the function specified by the notation is performed. The user receives confirmation of entry from an audible click and display of the requested data. Selecting the “display data” notation on the main menu changes the panel into a centralized display unit (CDU) on which the values of the automatically recorded variables are shown (Fig 1). The user can also enter data manually through the touchpanel by calling up various screen menus and making appropriate selections from lists presented on screen.

Mounted on the back of the Modulus II system, the CPU processes the signals provided by the monitoring devices used in this study: an Ohmeda 2110 NIBP monitor, an Ohmeda 5400 volume monitor, an Ohmeda 5100 oxygen analyzer, an Ohmeda Biox 3700 pulse oximeter, a Datex Normocap carbon dioxide analyzer, and a Hewlett-Packard 78533B electrocardiogram (ECG) monitor. Data from the first two monitors are acquired through serial communication lines. The signals from the other monitors are fed into the AARK through a multiplexed analog-to-digital converter. The heart rate is provided by the ECG monitor. Figure 2 shows how the signals from the monitors are processed by the CPU. The processed data are then sent to the two