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Automated anaesthesia record systems, observations on future trends of development *

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Abstract

The introduction of electronic anaesthesia documentation systems was attempted as early as in 1979, although their efficient application has become reality only in the past few years. Today, documentation technology is offered by most of the monitor manufacturers and new systems are being developed by various working groups. The advantages of the electronic protocol are apparent: Continuous high quality documentation, comparability of data due to the availability of a anaesthesia data bank, reduction of the workload of the anaesthesia staff and availability of new additional information.

Disadvantages of the electronic protocol have also been discussed. Typically, by going through the process of entering data on the course of the anaesthetic procedure on the protocol sheet, the information is mentally absorbed and evaluated by the anaesthetist. This mental processing of information may, however, be missing when the data are recorded fully automatically – without active involvement on the part of the anaesthetist.

It seems that electronic anaesthesia protocols will be required in the near future. The advantages of accurate documentation and quality control in the presence of careful planning will outweigh cost considerations. However, at this time, almost none of the commercially available systems have matured to a point where their purchase can be recommended without reservation. There is still a lack of standards for the subsequent exchange of data and a solution to a number of ergonomic problems still remains to be found.

Introduction

The accurate documentation of an anaesthetic procedure is an important source of information for the assessment of the course of anaesthesia. It enables the anaesthetist to recognize trends in the monitored parameters which require the initiation of therapeutic measures. Furthermore, it may help the attending anaesthetist in making a rapid evaluation of the state and course of an anaesthetic procedure performed by the resident in training. Moreover, accuracy of anaesthesia documentation is an increasing requirement throughout the world today. Inadequate documentation generally results in a situation where, rather than the patient suffering from possible damage needing to prove that this occurred as a result of an error on the part of the anaesthetist – it is the physician who has to provide proof of the correctness on his action. In the absence of written documentation a court decision against the anaesthetist can be reversed only with great difficulty.

According to a number of investigations, 20% of the total anaesthesia time is required for documentation. This factor may vary depending upon the duration of the surgical procedure [1–4]. In situations demanding full attention on the part of the anaesthetist (induction of an emergence from anaesthesia, critical situations, mishaps) simultaneous documentation is almost impossible. Then, it is likely that anaesthesia records may later be updated from memory with varying degrees of accuracy. An electronic protocol

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is ideally suited to fill this gap and thus enables the anaesthetist to concentrate more on the patient and less on the correct documentation.

Requirements and goals for system design

Electronic anaesthesia documentation should be designed to achieve the following goals:

- Standardized and legible documentation
- Accurate and continuous documentation similar to a black box recorder
- Simplified documentation by automatic or interactive recording of monitor and anaesthesia machine data
- Individual documentation based on the specific requirements of the hospital or of the performed intervention
- Instant availability of the patient's previous anaesthesia records and of documented warnings
- Automatic evaluation of data on provided services, quality control and cost accounting
- Standardization of protocols allowing a comparison of the quality of services provided by different hospitals
- Scientific evaluations

A number of specific minimum contents may be regarded mandatory for anaesthesia documentation:

- Data for the description of a specific anaesthetic procedure, including e.g. vital parameters of the patient and administered medications.
- Quality control data, including the documentation of specific events, mishaps and complications as well as information as to the intrumentation used, personnel, anaesthetic technique and, last not least, preoperative risk factors of the patient.
- Data for the assessment of primarily administrative services, including information as to the duration of anaesthesia, number of staff members present, rooms used, and services provided.

These data serve both as the basis for internal cost accounting and for the calculation of patient invoices. The minimum medical contents of anaesthesia documentation have been described in the past by the different specialty organizations and are constantly updated [5–7]. Data for recording of services provided must be adaptable to the individual requirements of the hospital or to a particular accounting system [8–12].

Strategies for database design

Data structure used for documentation of anaesthesia related information has to be flexible, because the stored data are markedly different from those used, e.g. for a census. The structure of anaesthesia data bank should also allow the storage of continuously recorded vital parameters (e.g. ECG monitored heart rate) throughout the anaesthetic procedure. Indeed, invasive monitoring and extensive surgical intervention exert a significant influence on the extent of available data. Typically, during cardiac surgery extensive monitoring provides a large number of data which have to be stored within a relatively short period of time. On the contrary, only a few data suffice during the surgical treatment of e.g. an uneventful hand injury to describe the stable condition of a patient.

With a view to the continuous development of medicine, it is mandatory that new data items can be added into the data bank structure later.

Therefore, it becomes clearly apparent that simple relational data bank concepts are not sufficient for the outlined requirements. This is particularly true for spreadsheet tables which have been used with a few of the commercially available products. Modern data bank concepts are much more flexible. They may have in built case-specific descriptions for the required data. Thus, they only store data regarded as relevant for a particular anaesthetic procedure. The time required for data storage can thus be effectively reduced [11, 13–16].

User interface

An electronic anaesthesia protocol, as a rule, implies the introduction of the computer display into the workplace of the anaesthetist. Ergonomic requirements applicable for display equipped non-medical workplaces must be fulfilled. It is the aim of the electronic anaesthesia protocol to completely dispense with handwritten records. Graphic displays, possibly color displays, are best suited to accurately present the different recorded data.

The simple intuitive operation of the anaesthesia computer is a basic requirement for the successful application of electronic data processing in anaesthesia. Computer software development should be based on general applications (e.g. good graphic programs) and graphic user surfaces. The use of touch screens or other display devices (mouse, track ball) may greatly

facilitate the entry of data. It should further be possible to enter certain data using a standard keyboard, as this provides the most rapid display of general data or, e.g. drug dosages. However, displaying a picture of a keyboard on the screen and keying in of text with the mouse is unacceptable and should be avoided [4, 8, 17].

Due to the price development of personal computers as well as to their increased capacity, most current systems are likely to include micro computers (PC) at the workplace. They should be connected to a client-server network to ensure additional safe storage of patient data outside the operating theatre by means of data transfer to a server. A patient passes through a number of different workplaces (premedication room, induction room, operating theatre, postoperative bedside visit). At all these points, access to his or her data is essential.

Interfaces to anaesthesia equipment

Today, electronic data processing allows the immediate storage of different monitored parameters, thus eliminating the need for time consuming handwritten entries. To perform this task, the PC has to be connected to a number of other devices. Unfortunately, a lack of standardization with regard to the interfaces for the hardware is a reality. Standardization of different interface protocols for the data transfer to the PC are required [11].

From a technical point of view the interfaces should also fulfil the respective legal requirements for electrical safety (e.g. optical isolation, power failures). In some countries, government regulations demand the inspection of interfaces by an official technical inspection organization. In Germany that is the case for all types of medical equipment – their production requires government approval.

System development, own experiences

Introduction of electronic anaesthesia documentation systems was attempted as early as in 1979, although their efficient application has become reality only in the past few years. Today documentation systems are offered by most manufacturers of monitors. In addition, new systems are being developed by various working groups [2, 4, 8, 11, 12, 17–21].

For the system developed by our group (NARKPROT) [11] handwritten protocols were analyzed as to the applied procedure of data recording. We subsequently attempted to convert this algorithm into a software application. Each entry was designed so that it could be performed more rapidly (or at least as rapidly) than the recording of handwritten data on the paper record. Data are displayed in the usual manner, i.e. the anaesthesia record used at our hospital is almost identically reproduced on the display. Since the resolution of available PC displays is not sufficient to show an A4 page in detail, the automated record was divided into different sections for display on the screen. The individual sections can be displayed by pressing a 'hot key'. The course of the vital parameters is continuously displayed on the screen.

Data transfer to the PC is performed interactively from the monitors, using an universal interface developed by our group. The existing working routine of the staff was left unchanged. Typically, the anaesthetist first decides when he wants to record a blood pressure value. Then, he keys in the respective symbol shown on the display. The actual monitored data are subsequently displayed in a window, to be checked for the presence of artefacts, and automatically entered. Thereafter one to ten seconds are thus required to enter a blood pressure value (systolic, diastolic and mean pressure).

Advantages, disadvantages and future trends

The use of computers at the anaesthetists workplace enables him to get reliable information on various topics that are far behind monitoring.

Recently, disadvantages of the electronic protocol have also been discussed [26–31]. By going through the process of entering data on the course of the anaesthetic procedure on the protocol sheet, the information is mentally absorbed and evaluated by the anaesthetist. This information may, however, be lost when the data are recorded fully automatically – without active involvement on the part of the anaesthetist. Studies on human performance are needed to elucidate the effect of automated records on anaesthesia quality. Primarily with a view to this precarious situation we do not allow fully automatic recording of data in our system. Instead, we oblige the anaesthetist to play an active role in the documentation. We feel that fully automated anaesthesia records could be used only if intelligent alarms are integrated into these systems [29,

32, 33]. The costs of this kind of computer supported workplace is very realistic (DM 15000 - 25000). In each operating theatre, the price of a microcomputer, interface, software, and the proportional costs of the network and server must only be taken into account. Cost estimates made by the commercial manufacturers are usually substantially higher.

Future technologies, like multimedia, may e.g. allow for the presentation of anatomic pictures (e.g. during regional anaesthesia) or information on drug interactions. These features can help to provide better education during the course of the procedure. Computerised anaesthesia simulators are on their way into clinical practice [24, 25]. It would be tempting to integrate these tools into the record keeping system.

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