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Comparison of manual and automated documentation of adverse events with an Anesthesia Information Management System (AIMS)

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Abstract. In this study, an Anesthesia Information Management System (AIMS) is used for the comparison of manually recorded adverse events with automatically detected events from anesthesiological procedures. In 1998, data from all anesthesia procedures, including the data set for quality assurance defined by the German Society of Anesthesiology and Intensive Care Medicine (DGAI), were recorded online with the documentation software NarkoData 4 (IMESO GmbH, Hüttenberg, Germany) followed by storage into a relational database (Oracle Corporation). The occurrence of manually recorded adverse events, as defined by the DGAI, is compared with automatically detected events. Automated detection was done with SQL-statements. The following adverse events were selected: hypotension, hypertension, bradycardia, tachycardia and hypovolemia. Data obtained from 16,019 electronic anesthesia records show that in 911 patients (5.7%), one of the selected adverse events was documented manually whereas in 2,996 patients (18.7%) a adverse event was detected automatically. The incidence of automatically detected events is obviously higher compared to manually recorded events. With the help of an AIMS, automatic detection proved significant deficiencies in the manual documentation of adverse events.

1. Introduction

In 1993, the German Society of Anesthesiology and Intensive Care Medicine published a data set which lists the type of data to be collected during anesthesia as well as aspects that are relevant to quality assurance [1]. Comprising of 112 individual fields, this list has since then been considered to be the minimum standard for quality documentation of anesthesia in Germany. A list of adverse events was defined by the DGAI. The use of the term "adverse event" in this paper is based on a definition laid down by the DGAI. In the documentation of adverse events, the anesthesiologist plays a key role. The data collected in this study should help to draw conclusions about the quality of performance and results of anesthesia in our department.

The effect of the documentation instrument (manual as well as automatic) was not considered for the definition of the DGAI, although it has been repeatedly proven that computer-supported online documentation systems [2,3,4,5,6] have a positive influence on the quality of data.

The influence of the method of documentation on the frequency of recorded adverse events was investigated by using data records from more than 20,000 anesthesiological procedures recorded by an Anesthesia Information Management System (AIMS) in 1998. Automatically

detected events were used to examine and scrutinize documentation in order to detect suspected deficiencies in manual documentation.

2. Methods

In 1998, the Department of Anesthesiology and Intensive Care Medicine at the Justus-Liebig-University Giessen recorded anesthetic procedures, including duration of stay in the recovery room, with the online anesthesia documentation software NarkoData Version 4 (IMESO GmbH, Hüttenberg, Germany) [2]. This program records all information relevant to anesthesia including drugs, laboratory data, corresponding vital data as well as the data set for quality assurance defined by the DGAI [1]. Due to missing interfaces with older vital data monitors, only 69 of 112 work stations (i.e. 62 %) used automated data transfer. The rest of the data was entered manually via mouse and keyboard. Mean arterial blood pressure (MAP) and heart rate (HR) were generally recorded at least every 5 minutes when using non-invasive measurements and every 3 minutes when using invasive measurements for blood pressure.

Protocol data files were imported into the database (Oracle 7, Oracle Corporation), following plausibility and integrity checks run within the documentation program.

Anesthetic reports manually recorded on paper were subsequently entered by research assistants into the same software system (NarkoData). The program Voyant by Brossco Systems (Espoo, Finland) was used for evaluation. With this program, SQL-scripts (Structured Query Language) could be generated via a graphic interface or entered directly into an editor.

As with similar projects, we were mainly preoccupied in the first years with the installation and perfection of routine use of the AIMS. An increased quality documentation has only been possible since the beginning of 1998.

The DGAI defines adverse events as follows [1]: events, which occur during anesthesia and which cause potential harm to the patient, requiring therapeutic action. These definitions, as well as other relevant information concerning quality documentation, could be accessed by medical personal through departmental intranet with an HTML-Browser (Netscape Communication Corporation), located at every anesthesia workstation. Adverse events are recorded manually via mouse using "drop-down menus" in a dialog box of the anesthesia documentation software.

To automatically detect adverse events from the medical database, queries have been designed using the SQL database language. Special care was taken to conform to the definition of the DGAI concerning adverse events, requiring that potential life-threatening changes of parameters were linked to therapeutic interventions (table 1).

Non-plausible zero and extreme values were removed from the database. In order to evaluate the number of artifacts, 5 % of the data records (at least 20) were selected randomly and compared with the electronic anesthesia record by two anesthesiologists. Post surgical data records (i.e. those not collected online with the AIMS) were excluded. Data from patients under the age of 14 as well as those from patients managed with cardiopulmonary bypass were also excluded.

The required data were exported via structure query language (SQL) from the database into the statistics software SPSS for statistical evaluation (SPSS Software GmbH, Munich). An anesthesiological record can contain several adverse events or automatically detected events. Patients with several similar events were only taken into account once.

Table 1: Definitions of SQL-queries for automatic detection of adverse events.

adverse events	definition of the query
hypotension	decrease in MAP > 30 % in 10 minutes ***and*** administration of a vasoconstrictor within a maximum of 20 minutes following onset of the decline in MAP (dosage was not taken into consideration).
hypertension	increase in MAP > 30 % in 10 minutes ***and*** administration of an anti hypertensive drug within a maximum of 20 minutes following onset of the increase in the MAP.
bradycardia	HR < 50/min. for at least 5 minutes ***and*** administration of a drug to increase the HR within a maximum of 15 minutes following the first measurement of the event.
tachycardia	HR > 100/min. over a period of 5 minutes (max. 11 minutes) ***and*** administration of a drug to lower the HR within a maximum of 15 minutes following the first measurement of the event.
hypovolemia	HR > 100/min. and SAP < 100 mmHg for 10 minutes ***and*** administration of colloids, erythrocyte concentrates or fresh plasma within a maximum of 20 minutes following the first measurement of the event.

3. Results

Data obtained from 16,019 electronic anesthetic records, after implementing exclusion criteria, show that one of the adverse events was documented manually in 911 patients (5.7 %), whereas a corresponding event was detected automatically in 2,996 patients (18.7 %). Anesthesia records were used for random checks of the automatic detection of 20 events and showed a success rate of 100 %. The actual occurrence of an automatically detected event corresponded to an adverse event.
Table 2 demonstrates the incidences of surgical procedures with manually documented adverse events compared to procedures with automatically detected events. The relative frequency of patients with at least one automatically detected event is distinctly higher than in patients with manually recorded adverse events.

Table 2: Incidences of adverse events from 16,019 patients according to the different type of documentation.

adverse event	manual	automatic
hypotension	339 (2.1 %)	1276 (8.0 %)
hypertension	183 (1.1 %)	1009 (6.3 %)
bradycardia	408 (2.5 %)	623 (3.9 %)
tachycardia	50 (0.3 %)	212 (1.3 %)
hypovolemia	14 (0.1 %)	170 (1.1 %)

4. Discussion

The current method of quality documentation in anesthesia has been considered an appropriate tool for internal and external quality assurance by the majority of authors since its introduction in Germany in 1993 [1]. Its practicability has been demonstrated in numerous publications based on extensive studies [7,8]. However, in spite of comparable results, the problem of interpreting the variability of adverse events remains currently unresolved. The variability in the number of detected adverse events can only then be an indicator for the quality of anesthesia care if proper documentation is available. In the above mentioned studies [7,8], predominantly hand-written anesthesia records were analyzed. Data were either subsequently entered into a computer manually or using machine readable anesthesia records.

The primary aim of this study was to verify a suspected deficit in voluntary manual documentation of adverse events. Therefore, it was particularly important that the definition of the selected automatically detected events corresponds to the definition of the DGAI [1], they should have been recorded immediately on occurrence by the responsible anesthesiologist.

Our results demonstrate that manual documentation records only a fraction of adverse events. This is supported by the findings of Sanborn et al. [4]. According to their study using an AIMS with automatic data transfer, a mere 4.1 % of 434 automatically detected adverse events were recorded voluntarily. In their study, tachycardia was the least recorded event, with only 2.0 %, with the largest number of recorded events being hypotension (37.5 %).

Some authors indicate that artifacts may be detected falsely as adverse events and thus have a negative influence on the quality of documentation [9]. A study by Sanborn et al. [4] demonstrated that merely 5 % of all adverse events (total of 494) were feigned by artifacts, which was equivalent to 0.46 % in a group of 5,454 patients. All SQL statements defined for the detection of adverse events in our study showed a success rate of 100%. Hence, an influence by artifacts can be excluded. Because of the large number of patients, validation of the electronic detection was restricted to samples. A visual analysis of all anesthetic records would be next to impossible due to the very complex definition.

In contrast to the study of Sanborn et al., we associated two criteria for the detection of events. Sanborn et al. used just one criterion for the detection of a parameter. Values had to exceed or fall below a defined limit in a set period of time in order to be detected automatically. Our definition of perioperative adverse events differs from that in other studies (7), because in our definition the reading of a parameter which could be harmful to the patient and the consecutive therapeutic intervention lead to detection of the event. This association proves that the anesthesiologist must have attached clinical importance to the event.

The incidence of conventionally recorded adverse events (22.2 %; 66 different types), found in our department in 1998 during the quality assessment according to the DGAI, is comparable with results of other German authors. Heinrichs et al. [8] indicate in their study that the probability of an adverse event occurring in large tertiary care hospitals lies between 16 and 26 %. In an external quality management study of hospitals in Hamburg (Germany) in 1998, an adverse event was recorded in 21,340 patients out of 164,352.

Depending on the type of adverse events, we were able to demonstrate a deficit in manual recording of up to 300%. Based on data from manual recordings, the results of the quality assurance according the DGAI guideline in our department is in accordance with those of other comparable German departments. Because of the low rate of manual event recording found in our study, we suspect that the same inaccuracy of manual documentation of adverse events exists in all departments of anesthesiology. Thus, we assume this to be a general problem of this particular method of quality assurance.

With the help of an AIMS, it was possible to prove a deficiency in manual documentation of adverse events. Electronic monitoring is indeed usable as an appropriate tool for a more precise documentation of the incidence of recorded adverse events. Additionally, these systems provide an increase of detail in definitions and complete data sets, made available for quality assurance projects and the development of risk indices.

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