Improved Data Quality by Pen Computer-Assisted Emergency Room Data Recording Following Major Trauma

A Pilot Study

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Abstract

Background: Quality management is a decisive factor in optimizing the treatment of major trauma cases. In this context high-quality data recording is of fundamental importance. Regarding data quality, "on-line" – especially pen computer-based – recording techniques are favored. Up to now, however, there is no study really proving a higher quality of emergency room (ER) data by use of such a technique in comparison with a paper-based technique.

Material and Methods: In all major trauma cases a standardized ER data recording, using "TraumaWatch", was performed; the study collective was divided into two subgroups: the "pen" collective using a pen computer-based technique and the "paper" collective using a paper-based technique. Data quality was defined as level of data completeness.

Results: A total of 207 major trauma cases underwent ER management. There was no statistically significant difference between the "pen" (n = 135) and the "paper" collective (n = 72) regarding gender, age, mechanism of injury, injury severity, and duration of ER management. There was no correlation between degree of injury severity and level of dataset completeness. Total dataset completeness was significantly higher within the "pen" collective (93.6% vs. 82.5%; $p < 0.01$); the same applies to the core dataset (Utstein style) completeness (97.3% vs. 91.3%; $p < 0.01$).

Conclusion: Defining data quality as level of data completeness, a pen computer-based recording technique, which allows easy and fast – real-time – data acquisition during ER management, seems to be superior to the conventional paper-based technique.

Key Words
Pen computing · Data recording · TraumaWatch · Emergency room · Major trauma

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Introduction

Numerous experts [1–3] rate the initiation of an extensive quality management system as a decisive factor in optimizing the treatment of patients with major trauma. Such a quality management system basically consists of component documentation, data analysis, and the valuation of the treatment process data within a quality management task force [4]. Although the instrument of documentation is assessed to be of fundamental importance within such a quality management system, different studies have shown, that the quality of trauma data reporting is very poor and has to be improved [3].

Regarding data quality, "on-line" data-reporting techniques with real-time data acquisition during emergency room (ER) procedures are favorable [4, 5]. Among various on-line data-recording techniques described in the literature [6–9], the pen computer-based technique is considered to be superior to the others [4]. Up to now, however, there is no study really showing, that the quality

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of data acquired by an on-line pen computer-based technique is better than that acquired by a conventional, paper-based, technique. Subject of this study was therefore to compare the quality of ER trauma management data of a paper-based recording technique with that of a pen computer-based recording technique.

TraumaWatch

The demand for improving trauma data documentation quality was the starting point for the development of a complex trauma data documentation system at our department in 1997. After nearly 3 years of research, development and intensive clinical testing, the system named "TraumaWatch" was introduced into routine ER trauma management [16].

"TraumaWatch" is a three-modular documentation concept (see Figure 1); all modules have the same dataset in common: it completely includes the recommendations for uniform reporting of data following major trauma of the German Society of Traumatology (DGU) [10, 11] as well as the International Trauma Anaesthesia and Critical Care Society (ITACCS) – the Utstein style [12]. This core dataset has been extended by an individual, hospital-specific, dataset for internal quality management. Therefore, the prerequisites for an internal and external quality management on a national as well as an international level are established in all three modules.

The difference between the three modules is the method of data recording: module I exclusively consists of a traditional paper-based trauma data record, whereas module II additionally contains a software, which allows retrospective electronic recording, analyzing and the export of the primarily handwritten trauma data records. Module III – the "on-line", pen computer-based, ER data-recording system – represents the high-end solution of "TraumaWatch" (see Figures 2 and 3). Data acquisition is already performed during ER management with a portable computer – a pen computer; in this computer, data entry is not being done by keyboard but by a pen just as writing on an electronic form.

Material and Methods

In all patients admitted to our hospital during the study period, a standardized ER trauma data recording was carried out by a "documentation assistant" parallel ("on-line") to the diagnostic and therapeutic ER procedures. As the trauma data-recording system, "TraumaWatch" was used. For this, the "documentation assistant" (medical students involved in various scientific research projects at our department) passed only a brief introduction in the use of "TraumaWatch". As a member of the ER trauma team, this person was exclusively responsible for ER trauma data recording.

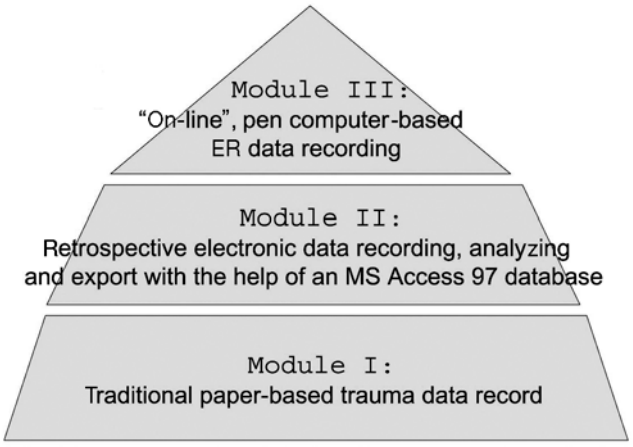

Figure 1. Three-modular concept of "TraumaWatch".

Regarding trauma data recording the total study collective was divided into two groups: the "pen" collective by using "TraumaWatch" module III (primarily pen computer-based documentation) and the "paper" collective by using "TraumaWatch" module II (primarily handwritten paper-based documentation; secondary data transmission into a desktop PC). The assignment to the "pen" or the "paper" collective was according to the availability of the pen computer upon admittance of the trauma patient at the ER (the pen computer was not only in use at the ER, but at other locations, e.g., intensive care unit, for documentation purposes).

In this study data quality was treated as equivalent to the level of dataset completeness. The level of dataset completeness was defined as the relation between the actually documented parameters and the maximum of parameters, which can be documented for each patient. The maximum of parameters, which can be documented for each patient, was not constant, because of variations in ER management procedures in each patient. Within the two collectives in each dataset the level of total dataset completeness as well as of core dataset completeness was checked. As core dataset we defined the dataset, which completely comprises the recommendations for uniform reporting of data following major trauma of the DGU [10, 11] as well as the ITACCS – the Utstein style [12]. The total dataset comprises the core dataset expanded by our hospital-specific dataset.

Figure 2. Pen computer-based trauma data recording (module III of "TraumaWatch") already during ER management in a major trauma case.

All values in the tables are expressed as percent unless otherwise indicated. The ascertained dataset completenesses for each patient were tested for the two collectives by using the Wilcoxon test for unpaired collectives (Mann-Whitney U-test) and the χ^2-test where appropriate. Statistical significance was set at $p < 0.05$. Statistical analysis was performed using specialized statistical software (SPSS version 11.0 for Windows), depicted as box-and-whisker plots. Statistical consultation by the Department of Biometry and Medical Documentation of the University of Ulm, Germany.

Results

During the study period (May 1, 1999 to December 31, 2000) a total number of 207 ($n_{tot} = 207$) major trauma patients were admitted to our hospital and underwent ER management. Out of this total study collective, in 135 ($n_{pen} = 135$) patients a pen computer-assisted ER data recording and in 72 ($n_{paper} = 72$) patients a conventional paper-based ER data recording were conducted. There was no statistically significant difference between these two subpopulations regarding gender, age, mechanism of injury, injury severity, as well as duration of ER management (see Table 1).

The results regarding total dataset completeness within the total study collective as well as the two subpopulations are depicted in Table 2 and Figure 4. With 93.6% compared to 82.5% within the "paper" collective, the level of data completeness was significantly higher in the "pen" collective ($p < 0.01$). The same applies to core dataset completeness (see Table 2 and Figure 4): with 97.3% compared to 91.3% within the "paper" collective, the level of data completeness was significantly higher in the "pen" collective ($p < 0.01$).

Discussion

As pointed out, the instrument of documentation is assessed to be of fundamental importance within the quality management of major trauma patients [1–3]. In this context valid data, i.e., data acquired ideally real-time during ER management, is of utmost importance. However, at many trauma centers, data recording is still considered a more or less necessary evil and the majority of the trauma centers are far from an "on-line" ER data recording on a routine basis. Exemplary for the actual situation of trauma documentation is a study by Hamill et al. [13] from the year 2000, in which the authors examined the impact of a standardized trauma form for documentation in cases of major trauma compared with the routinely used formless trauma documentation. The conclusion of Palmer et al. [14] from the year 1992, that "only little attention is payed to documentation", still seems to be into effect, and Zintl et al. [3] summarize the actual situation regarding the overall quality of trauma data re-

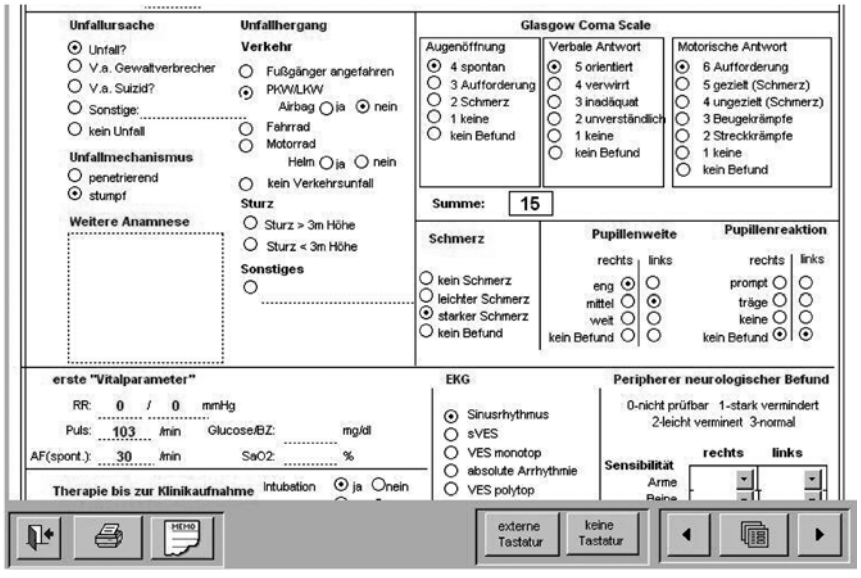

Figure 3. Screenshot of the the user interface of "TraumaWatch".

Table 1. Characterization of the total study collective as well as the two subcollectives ("pen" and "paper" collective) regarding gender, age, mechanism of injury, injury severity, and duration of emergency room (ER) management. CI: confidence interval; ISS: Injury Severity Score; NS: not significant; SD: standard deviation.

	Total study collective (n = 207)	Pen collective (n = 135)	Paper collective (n = 72)	p-value
Sex (%)				
• Male	70.1	68.8[a]	72.2[a]	NS (p = 0.93)
Age (years)				
• Mean	35.6	39.4[b]	33.6[b]	NS (p = 0.49)
• SD	22.1	21.6	22.9	
• 95% CI	32.8–38.4	35.7–43.1	28.8–38.4	
Mechanism of injury (%)				
• Blunt	95.7	96.3[a]	94.4[a]	NS (p = 0.79)
Injury Severity (ISS)				
• Mean	16.7	17.6[b]	15.5[b]	NS (p = 0.18)
• SD	15.3	15.5	15.0	
• 95% CI	14.5–18.9	14.7–20.5	12.1–18.8	
Duration of ER management[c] (min)				
• Mean	20.3	20.2[b]	20.4[b]	NS (p = 0.90)
• SD	11.7	11.4	12.6	
• 95% CI	18.8–21.8	18.2–22.2	17.7–23.1	

[a] χ^2-test
[b] Wilcoxon test (unpaired)
[c] The duration of ER management includes all therapeutic and diagnostic procedures without CT scans and special X-rays

Table 2. Level of documentation within the total study collective as well as the two subcollectives ("pen" and "paper" collective) specified regarding total dataset and core dataset. CI: confidence interval; SD: standard deviation.

	Total study collective (n = 207)	Pen collective (n = 135)	Paper collective (n = 72)	p-value
Total dataset (data completeness)				
• Mean	89.8%	93.6%[a]	82.5%[a]	
• SD	7.8%	4.7%	7.3%	p < 0.01
• 95% CI	88.7–90.8%	92.8–94.3%	80.8–84.2%	
Core dataset (data completeness)				
• Mean	95.1%	97.3%[a]	91.3%[a]	
• SD	6.0%	4.1%	7.3%	p < 0.01
• 95% CI	94.2–95.9%	96.3–97.7%	89.6–93.1%	

[a] Wilcoxon test (unpaired)

cording therefore as "very poor" and call for extensive improvement.

Within the field of "on-line" data acquisition, various research groups partly favor totally different reporting techniques: common are conventional, i.e., handwritten forms, mostly without any relation to an electronic data management system, even retrospectively [3, 15]. Compared with this, the audio- [9] and the videodocumentation technique [6–8] have to be emphasized. One remarkable feature of both reporting methods is, that during ER management no further (qualified) person for documentation purposes is necessary. This remarkable advantage is in turn handicapped by several deficiencies: first, retrospective videotape review is time-consuming, even with a PC-based technique [7], requiring 25–30% more time than the original trauma resuscitation (average duration of trauma resuscitation: 45–60 min [4]); second, task and personnel assignments must be made by individuals sufficiently knowledgeable to accurately recognize the event types and the people performing them; and third, not all events fit into a prospective classification system.

In contrast to such a documentation system, "TraumaWatch" as a form-based modular data-recording system is designed to use a "documentation assistant". Regarding data quality, we – like other research groups [4, 11] – attach high importance to this person, justifying this additional ER staff member [16]. At many trauma centers this task is assigned to interns [4] – at our hospital to medical students involved in different research projects of our department.

In this study, duration of ER management was not significantly different in the "pen" and the "paper" collective (20 min in each collective; see Table 1), i.e., the (primary) documentation time did not vary by charting method. In other words: regarding practicability, the soft- (TraumaWatch) and hardware (pen computer) for a primarily on-line electronic documentation were even equal to the routinely used documentation by hand and there was no prolongation of the duration of ER management by electronic documentation.

It is not likely that the nonrandomized character of our study did influence the study results, because it did not cause differences regarding gender, age, mechanism of injury, injury severity, or duration of ER management (see Table 1).

Because of the lack of similar studies within the setting of an emergency department, we have to compare these results with those of studies performed in other settings: Apkon & Singhaviranon [17], in their study on the impact of an electronic information system on physician workflow and data collection in the intensive care unit, and Menke et al. [18], in their study on a computerized clinical documentation system in a pediatric intensive care unit, found no difference regarding the amount of time consumed dependent on the charting method. Additionally, Apkon & Singhaviranon [17] report of a significantly more detailed electronic than handwritten

document: 50% more descriptors overall and some data elements that were not recorded in any handwritten documents. In our study we also found a significantly higher level of dataset completeness in the electronic document compared to the primarily handwritten document: 93.6% versus 82.5% ($p < 0.01$) regarding total and 97.3% versus 91.3% ($p < 0.01$) regarding core dataset (Utstein style). Lossius et al [5], in a retrospective study on 225 major trauma cases, were able to obtain at least 47% of the recommended core dataset (Utstein style). What are the reasons for this poor level of core dataset completeness compared with our results? From our point of view there are three main factors:

(1) the fact that the medical records had been written by ER staff members pertaining to the assessment and treatment of the trauma patients and not by a "documentation assistant", an additional ER staff member, solely responsible for trauma data recording. It is known that the first few minutes in the treatment of major trauma patients are crucial, reflecting on their survival; therefore, ER management of major trauma cases is performed under stress and requires a team approach in which the multiple concordant activities of a number of specialists have to be performed under pressure [7, 8]. Thus, the quality as well as the level of completeness of ER trauma data recording must be limited in quality assurance programs without a "documentation assistant". Kulla [16] has really shown that the level of ER trauma dataset completeness is significantly higher in those cases, where documentation was performed by a "documentation assistant".

(2) the fact that the recommended core data from the Utstein style was collected "retrospectively". The quality of retrospective analysis of ER trauma data considerably depends on the quality of the primarily handwritten trauma forms. Davis [18] describes it as "what is seen and done needs to be noted in clear, concise, legible writing". So, primarily missed and therefore not documented data and/or primarily not legible data cannot be analyzed retrospectively. Corresponding studies in the field of prehospital trauma documentation showed a significant increase in dataset completeness in programs with an "on-line" compared to a "retrospective" documentation [18, 19].

(3) the charting method: our study has shown that the level of data completeness is significantly better with an electronic documentation technique. This technique has various advantages over a paper-based technique,

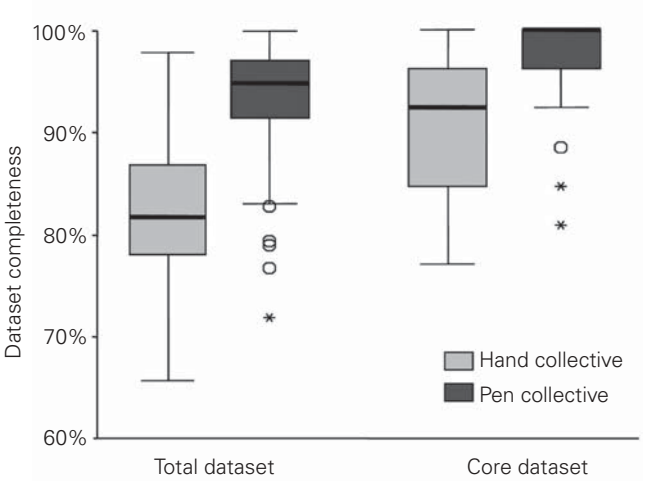

Figure 4. Level of documentation within the two subcollectives ("pen" and "paper" collective) specified regarding total dataset and core dataset.

e.g., implementation of automatic control of dataset completeness and dataset plausibility, enhanced ergonomy by pull-down menues and check-boxes as well as automatic timekeeping of ER procedures by an internal computer clock. Additionally, the total amount of time for documentation purposes is reduced, because there is no secondary (redundant) data entry into a computer. Quality management becomes faster and more easy.

Against this background, the conclusion of Lossius et al. [5] that it is difficult to retrospectively collect the recommended core dataset of the Utstein style and the call for a reduction of the number of core data, must be judged critically. We agree with the first part of this statement; regarding terms of quality management, < 50% of core dataset completeness is not acceptable. We disagree with the second part of their conclusion; a reduction of the number of core data might not be the solution of this problem, but the results of our study underline the necessity of an on-line documentation system and demonstrate the superiority of an electronic (pen computer-based) ER documentation over a conventional, handwritten ER documentation (97.3% core dataset completeness in our study with an on-line pen computer-based documentation).

Concerning the high level of dataset completeness in our study, it might be a more or less "academic discussion", whether core dataset completeness is 97.3% (electronic documentation) or 91.3% (handwritten documentation). However on closer examination, it becomes clear, that an electronic on-line documentation improves dataset completeness not only regarding core dataset, but also regarding hospital-specific dataset,

which is important for various internal quality management measures. They have – in view of various experts – the same improtance as external quality management activities concerning the entire process of ER quality management [4, 11].

Conclusion

Pen computer-assisted on-line ER trauma data recording allows easy and fast (real-time) as well as flexible data acquisition during ER management. Regarding data completeness this technique is superior to a paper-based technique.

Module III (pen computer ER data recording) of the documentation system "TraumaWatch" is in use at various trauma centers and university hospitals throughout Germany and Europe. Colleagues, interested in this documentation system are invited to contact us – we provide the software to (really) interested institutions free of charge.

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