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Dynamic Viewer of Medical Events in Electronic Medical Record

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Abstract

Medical record should enable doctors to comprehend the patient's history and select suitable medical treatment. In paper based medical records, medical events (examination, treatment etc.) are recorded successively, and problem oriented recording is difficult to be applied to patients with much information and a long history. Consequently it is not easy to understand the patient's history from paper based medical records. In order to solve this problem, we developed the flow sheet system in our electronic medical record (EMR). To make a flow sheet, we analyzed the structure of the medical event data. In this paper we introduced the medical event information model for our EMR. Furthermore, we clarified the specification of the data presentation on the flow sheet. We developed the flow sheet on the basis of these analyses. Because there are 3 layers in the vertical axis of the flow sheet, many items of the medical event can be displayed on the screen. When user clicks the cell, the corresponding detail data including images are shown. This system functions to link medical event items with a problem, and shows the bundled items on the flow sheet when the user selects the problem. We implemented this system in Osaka University Hospital. The number of the types of medical events and those of detail events in inpatients are 5.0±1.7 (mean±SD) and 60±47, respectively. The medical doctors in Osaka University Hospital evaluated this system, and concludes that the flow sheet data presentation makes comprehension of the patient's history easier than paper based records. As to the function of bundling the items relevant to the problem, they feel it is especially useful for patients with chronic disease. Thus the flow sheet data presentation in EMR is useful for medical practice.

Keywords:

electronic medical record, flow sheet, problem oriented medical record, structured data entry

Introduction

In medical practice, a doctor encounters problems in patient, prioritizes and organizes them according to the causal relation, gains insight as to their solution. After that he selects and performs the most suitable treatment, and monitors the progress of the patient. The medical record is not merely a record of the observations of a patient and the events the patient undergoes, but it must function to support the thinking process of the medical doctors. For this purpose, the problem-oriented medical record (POMR) was introduced by Lawrence Weed [1]. These days, one patient sometimes has a large volume of information, and aged patients or patients suffering from chronic disease sometimes have a long history. Although POMR is a prominent idea, it is difficult to apply to patients with a long history and a large volume of information in paper based medical records. The computer system has a feature that enables the entered data to be edited. Thus in computer based medical records, a dynamic view of the patient's history can be provided, that enables the user to take a broad view of the patient's history and also to focus on the specific problem.

Osaka University Hospital is a large hospital with 1,076 beds and 2,300 outpatient visits per day. The hospital was renewed in 1993, and at that time the large scale hospital information system was implemented [2,3]. We renewed and enlarged the system in 2000. The new subsystems were implemented, including PACS [4] and Electronic Medical Record (EMR).

Structured data entry is thought to be important in EMR [5-14]. We have developed dynamic template as a data entry tool to make the entered data structured [8, 12]. Based on the structured data entry, we developed the dynamic viewer for patient information including the order records, laboratory test results, examination reports, operation reports, progress notes and so on. We put all these data into the flow sheet format, in which line indicates the item, column indicates the date, and cells are denoted with short messages. The flow sheet data presentation is familiar to health care providers and it is known to be helpful to understand the patient's history. There are other systems which provide flow sheet data presentation [15-17]. Our system is so flexible that it can change its view according to the user's interest and requirement, and support the doctor's intellection.

Methods

Medical event information model

Medical records include a record of the observation of a patient's state such as progress notes, examination reports, operation reports, and also contains a record of orders such as prescription, injection, transfusion, treatment, examination, and operation. We call all of these a "medical event". To show all medical events in a flow sheet, they must be structured. We introduced the medical event information model for this. There are four major classes in our total medical record information model: patient general information class (including demographic data), medical event class, problem class, and summary class. The flow sheet structure corresponds to the medical event class. The details of the medical event class are as follows (Fig. 1).

The attributes of the medical event class are patient identifier, medical event type, date and time, and identifier of the user who recorded it. The medical event class has 2 subclasses; the observation record class and the order record class.

The order record class has several subclasses; prescription order, infusion order, treatment order, transfusion order, laboratory test order, radiology and physiological examination order, pathological test order, other examination order, operation order, rehabilitation order, meal order, medicine consultation order, and nutrition consultation order. Each of the above subclasses in the order record class consists of their contents classes. For example, the prescription order class consists of prescribed medicine classes whose attributes are medicine name, dosage, and how to take it.

The observation record class has 3 subclasses; the progress note record class made by medical doctors or nurses, the examination or operation report class, and vital measurement record class including blood pressure, heart rate, body temperature, etc. made by nurses in wards. The examination or operation report class has three subclass: laboratory test result class, general report class, and radiology image class. The laboratory test result class consists of laboratory test result unit classes, whose attributes are name of test, value and the unit. The progress note record class and the general report class are the subclass of description group class, which is consisted of description unit class. The description unit class consists of atom classes and narrative text class. Among the atom classes there is the relation of describing, which enables atoms to form structures [8, 12].

The relation between medical event and problem

The attributes of problem class are name of problem, start date, end date, consequence, department, and importance. The user can link medical events with the problem to show the medical events arranged according to the relevant problem. Medical events and problems are related in three ways: The first one is the relation between the problem and the type of medical events used to monitor it. The second is the causal relation between the problem and the data of the medical events used to diagnose it. The third relation concerns the problem and the medical events used to treat it.

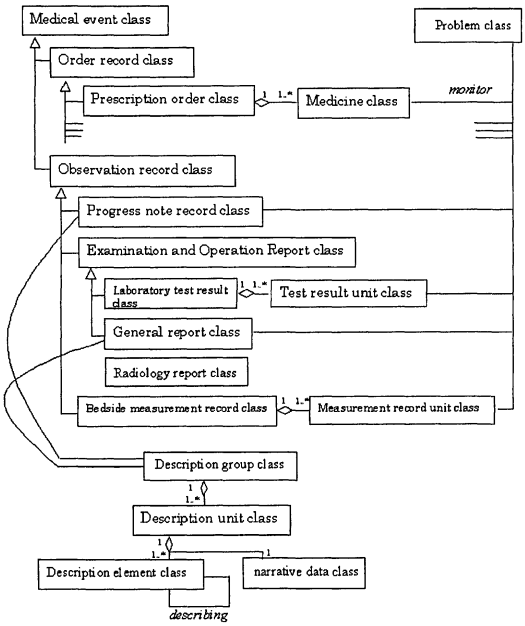

Figure 1: The part of the class diagram of the medical record information model. This figure focuses on the medical event class.

Design of the system

The image of our EMR is shown in Fig. 2. There are 4 windows; problem list window, patient's general information (demographic data, blood type, infection data, etc.) window, progress note window, and flow sheet window.

A short message is denoted on the cell of the flow sheet if data exist. When the user clicks the cell, the window showing the corresponding detail information appears (Fig. 3).

Because there are many kinds of medical events, they are structured in three layers. Table 1 shows the meaning of each layer. There are 17 types of medical events which are demonstrated on the first layer of the flow sheet (Fig. 3). The cells of the first layers denote the state of the event; for example, a triangle denotes a placed order but not being performed, a circle denotes a performed order; and a double circle denotes a performed order with report. When the user clicks the title of the first layer, the second layer appears which presents the details of the contents. For example, in a prescription order, the second layer indicates the name of medicines prescribed and the cell denotes the dosage (Fig. 4). In the progress note, data are presented in three layers. The second layer shows the department the patient consulted with and the cell denotes the name of doctor who

wrote the note. The third layer denotes the items

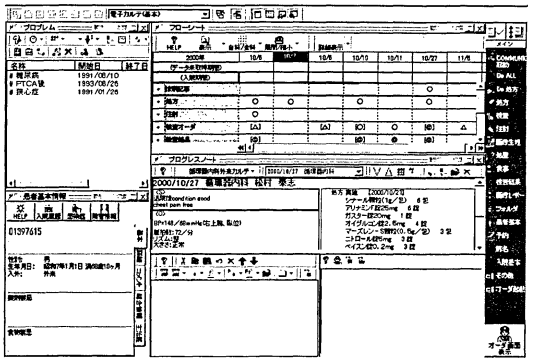

Figure 2: Total design of the EMR image. Upper left is problem list, lower left is patient general information, upper right is flow sheet, lower right is progress note.

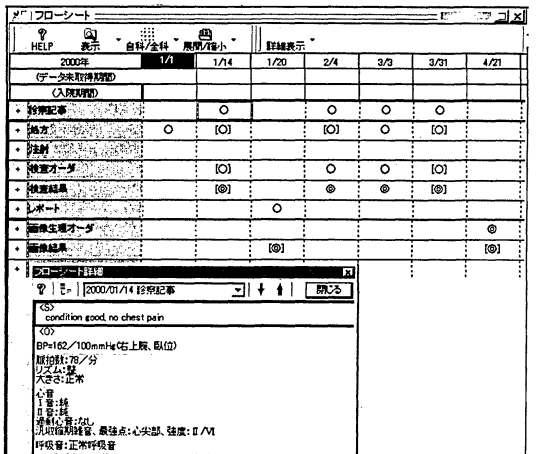

Figure 3: Example of flow sheet. The system initially presents the first layer of medical event type. In this example, progress note, prescription, infusion, laboratory test order, laboratory test results, radiology examination order, radiology examination image and report, and diet are presented as the items of the line. On the cells, marks demonstrating the progress of each order are presented. The window of the detail data is shown when the user clicks the cell. In this example, the progress notes of one day are demonstrated.

corresponding to the title of the template used, and the cell denotes the representative data. The general report has the same three-layered structure, but the second layer demonstrates the type of report.

The default of the horizontal axis of the flow sheet is date, but it can be changed to time, or the user can set the phase in which several days are combined. One cell sometimes corresponds to several events, that is, several events of the

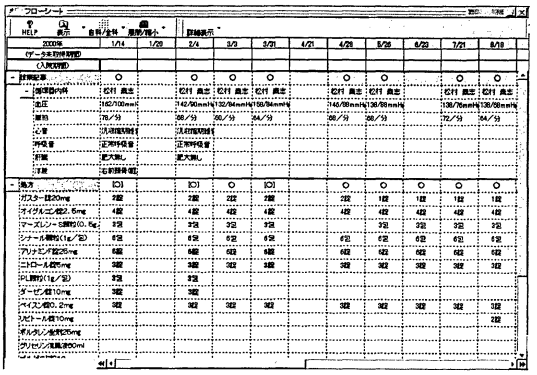

Figure 4: The second layer of the flow sheet. When the user clicks the name of the medical event type, the second layer appears. In this example, the department is shown as the second layer of consultation and the progress note as the third layer. The prescribed medicines are shown as the second layer of the prescription, and the dosage is presented on the cell.

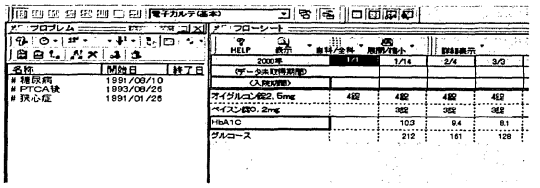

Figure 5: Example of the flow sheet on customized mode. Bundled items shown on this mode are linked with the problem. In this example, the items relevant to the problem of diabetes are shown. The items of the flow sheet are Euglucon2.5mg, Basen0.2mg, HbA1c, glucose (right window). The problem list includes Diabetes, Post PTAC, Angina (left window).

same type occur on the same period. In this case, the cell presents one of the data in brackets, while other data are concealed. When the user clicks the cell, the pop up window showing all these data appears.

To evaluate the progress in each problem of the concerned patient, user can bundled the shown items relevant to the problem. To bundle the items, the user has to link the items with the relevant problem beforehand. After this procedure, this system shows the selected items when the problem is clicked. We call this presentation "customized mode".

System configuration and data transmission

The EMR server (Express5800/180Ha x2, CPU: pentium III x4 and main memory 15Gb for each, Disk capacity: 705Gb) holds the main database system. The structure of the database is a simple flat one, whose role is just to keep the records. There are 850 client systems. When a client system requires data for a patient from the server, all of the patient data within the designated period (3 months for

inpatient, 1year for outpatient) are transferred to the client at one time. In the client system, all these are rearranged to form the flow sheet. After showing the flow sheet, all these data are retained on the memory. Thus the user can see any data on the flow sheet without waiting.

Table 1 structure of medical events in flow sheet

1st layer	2nd layer	3rd layer
Consultation	department	item of contents
Prescription	medicine name	
Injection	injection name	
Transfusion		
Treatment	treatment name	
lab test	lab test sample	
radiology exam	type of exam	
pathology exam	type of exam	
other exam	type of exam	
Rehabilitation	type of rehabilitation	
Operation	type of operation	
diet order	type of diet	
medicine consult		
diet consult		
lab test report	lab test item	
radiology exam report	type of exam	
general report	type of exam	item of contents

Results

This system was implemented in Osaka University Hospital in 2000. The flow sheet for 30 days is shown as a default. We counted the number of medical event types and events during 30 days in 20 randomly sampled inpatients. The mean number of event types in one patient for 30 days is 5.0±1.7 (mean ± SD) and that of events is 60±47.

We interviewed doctors about the usefulness of the flow sheet on their daily practice. All of them feel that the flow sheet data presentation is helpful especially when a patient undergoes many examinations and treatments. Compared with paper based medical records, they feel that the flow sheet helped them comprehend the patient's history more easily. As to the customized mode which can bundle the items relevant to the problem, they feel it useful especially for patients with chronic disease.

Discussion

When a patient has pleural problems, the physician in charge who wrote the record often consults with other experts. In this case, the latter see the medical record first to get the information relevant to his field. However, it is not so easy with paper based medical records to know what kind of examination has been undergone, when it was performed, and what the result was. By using our system, that information can be retrieved in less than 30 seconds.

When doctors see the patients with chronic disease, they monitor the several items which reflect the state of the disease. For instance, when a doctor sees a patient with diabetes, he monitors the body weight, blood glucose level, HbA1c, urine glucose and the amount of medicine for diabetes. When the doctor thinks the patent's diabetes is getting worse, he increases the medicine, and decreases it if the patient improves. In paper based medical records, it is not easy to monitor these items in progress note for a long time, especially in the patient with many problems. Doctor sometimes make a paper based flow sheet, but it takes time to post these data to the flow sheet. Our system enables the doctor to make a flow sheet automatically suitable for monitoring a problem. Template is available in our EMR system, by which the entered data are structured [8, 12]. The items corresponding to the template are presented in the flow sheet. Furthermore, the user can link with the elements of the context entered by the template. Although it is easy to enter the data in free text format, free text data limits the next evolution [9-11]. The flow sheet data presentation is one example of the benefits of the structured data entry.

Each ordering system and reporting system has a function to keep its history for each patient in its subsystem. Thus the user can seek the data that he wants to know. One feature of the flow sheet system is to keep the data comprehensively [15, 17]. The difference between the function to keep its history in ordering system and flow sheet is great. When the user sees the flow sheet of the patient, he can grasp the amount of information and their distribution at a glance. Then the user can know the outline of the patient within 10 seconds. During this process the user sometimes finds some features of the patient in the flow sheet, then focuses on the information that he is interested in. By continuing this process he gradually grasps the patient's history. By using only the separate history of each subsystem, the user can not achieve this. The history of each subsystem can be used only in cases where the user already knows the outline of the patient and wants to know the detail.

The ordinary EMR system has only a view of the progress note, which is similar to the paper based medical record. However, the area of CRT is too small to show enough progress note data at once. Thus the user has to scroll the window to see the past data. However, it is difficult to grasp the patient's history as a whole in this way, because the user wants to see the data scattered in the progress note all in one view.

The flow sheet system is for supporting the doctor's intellection. If the user has to wait when he accesses the detail data, his intellection is decoupled. In this system all the patient data within the designated period are transferred to the client system at once, then rearranged. Thus all these data are on the memory of client. The CPU speed of client

system is so fast that it does not take so much time to rearrange all the data.

A medical record information model was required for rearrangement of the patient data. We made the medical record information model for our EMR and introduced the part of it relevant to the flow sheet in this paper. The basic structure was presented on the diagram (Fig. 1). The items listed on the second and third layer of the flow sheet (Fig. 4) are the most significant ones, and others are concealed. We selected the items set to the second and third layer in each medical event type (Table 1).

Conclusion

We developed the flow sheet system and implemented it in the EMR of Osaka University Hospital. The flow sheet data presentation makes comprehension of the patient's history easier than paper based records. The function of bundling the items relevant to the problem is useful especially for the patients with chronic disease.

Acknowledgments

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References

[1] L.L. Weed, Medical records that guide and teach, N. Engl. J. Med. 278 (1968) 593-600.

[2] Takeda H, Matsumura Y, Kondo H, Imai K, Inoue M: Development of totally integrated hospital information system; an intelligent hospital in Osaka University. MEDINFO '92, 1992; 241-246

[3] Matsumura Y, Takeda H, Inoue M: Implementation of the totally integrated hospital information system (HUMANE) in Osaka University Hospital. MEDINFO '95: 1995; 590-593

[4] Takeda H, Matsumura Y, Kondo H, Inoue M, Kondo H, Takeda I, Miyabe S: System design and implementation of HIS, RIS, and PC-Based PACS at the Osaka University Hospital. MEDINFO '95: 1995; 430-433

[5] Kondoh H, Washiashi T, Sasagaki M, Nakamura H, Inamura K, Matsumura Y, Takeda H: Development and evaluation of HIS-RIS-Modality-PACS coupling: remote operation of PACS display terminal from HIS terminal in outpatient clinics. Medical Imaging 1998 3339: 1998; 466-473

[6] Takeda H, Matsumura Y, Satomura Y, Yamazaki S, Kimura M: Thesaurus for a Japanese Electronic Patient Record System and Standardization for Terms/Vocabulary. Jpn. J. Med. Inform.17(3) 1997; Supple:255-257

[7] Takeda H, Matsumura Y, Okada T, Kuwata S, Inoue M: A Japanese approach to establish an electronic patient record system in an intelligent hospital. Int. J. Med. Inform. 1998; 49: 45-51

[8] Matsumura Y, Takeda H, Okada T, Kuwata S, Hiroaki N, Hazumi N, Inoue M: Devices for structured data entry in electronic patient record. Medinfo '98., 1998; 85-88.

[9] Moorman PW, van Ginneken AM, van der Lei J, van Bemmel JH. A model for structured data entry based on explicit descriptional knoeledge. Method Inform Med 1994; 33: 454-63.

[10] Cimino JJ. Data storage and knowledge representation for clinical workstations. Int J Biomed Comput 1994; 34: 185-94.

[11] Giregory J, Mattison JE, Linde C, Naming Notes: Transitions from free test to structured data entry. Method Inform Med 1995; 34: 57-67.

[12] Matsumura Y, Okada T, Kuwata S, Nakazawa H, Hazumi N, Kusuoka H, Inoue M, Takeda H: Multi axes data presentation in electronic patient record based on structured data entry. EPRiMP 1998; 188-192.

[13] van Ginneken AM, Stam H, van Mulligen EM, de Wilde M, van Mastrigt R, van Bemmel JH ORCA: The versatile CPR. Method Inform Med 1999; 38: 332-338.

[14] Yamazaki S, Satomura Y Standard method for describing an electronic patient record template: application of XML to share domain knowledge. Method Inoform Med 2000; 39: 50-55

[15] McDonald CJ, Barnett GO. Medical-record systems. In: E. H. Shortliffe and L. E. Perreault, eds. Medical Informatics – Computer Applications in Health Care., vol., E. H. Shortliffe and L.E. Perreault, eds. Reading MA: Addison-Wesley, 1990, pp. 181-218

[16] Tange HJ, Dreessen VAB, Hasman A, Donkers HHLM. An experimental electronic medical-record system with multiple views on medical narratives. Comput Meth Prog Biomed 1997; 50: 157-72.

[17] Tange HJ Consultation of medical narratives in the electronic medical record. Meth Inform Med. (1999); 38:289-93.

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