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Computerized patient record for a Department of Respiratory Rehabilitation

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ABSTRACT. *Computerized patient record for a Department of Respiratory Rehabilitation. L. Ballardini, A. Spanevello, E. Radice, G.B. Migliori, A. Satta, M. Neri.*

A computerized patient record (CPR) system plays an essential support role in the efficient functioning of the clinical and research services of a medical centre. We report the experience gained in developing a CPR for the Respiratory Rehabilitation Department (RRD) of the Tradate Medical Center of the Salvatore Maugeri Foundation, with specific reference to Out-patient (OP) and In-patient (IP) Units.

The CPR was developed locally under the guidance of the Bioengineering Department. Several items implemented and strategies adopted are described and grouped in relation to broader objectives, such as the improvement of health-care quality, the enhancement of personnel productivity and reduction in costs, the support of clinical and health service research and the accommodation of future developments. In particular, we describe the design and implementation of anamnestic, physical and admission data collection, specifically orientated to respiratory diseases. Daily use of the CPR in the OP and IP units and its potential outcome for research and management support are also studied in detail.

On the basis of our experience (1,251 out-patient examinations, 650 in-patient clinical admission cards), the computerized patient record seems a useful way of providing better health-care and a more comprehensive coverage of the rehabilitation process of patients in a Respiratory Rehabilitation Department.

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Computerized patient record (CPR) systems have been extensively used to support the pursuit of fundamental objectives, such as the improvement of health-care quality, the enhancement of health-care personnel productivity and cost reduction of health-care delivery, the support of clinical and health service research, and the accommodation of future developments, policy, management and finance [1–8].

Research has shown that an improved quality of health-care can be obtained by: 1) the integration of patient information within single departments and, on a larger scale, throughout the hospital [1–4]; 2) a well-defined data set for clinical history, physical examination and clinical outcome of out-patients (OP) and in-patients (IP) who attend the department [3]; 3) direct physician use of the computer, obtaining a high degree of accuracy and instancy in inserting data, and reducing the risk of loss of data [3, 8]; and 4) better legibility and conservation of documents [1, 5, 6]. The daily use of a computer system for patient care can also provide useful long-term support to scientific research [1, 4–6], and the identification and coding of clinical variables could support retrospective studies in terms of data screening and protocols.

Nevertheless, neither paper-based nor existing computer-based records can effectively support all these objectives today. The majority of current hospital information systems (HIS) are strongly oriented towards financial application and their CPR format is not appropriate to cater for medical effectiveness and research [3]. Moreover, whilst a small number of CPR systems have been specifically orientated to a Respiratory Medicine Department [5, 6], none have been found reported in the literature that are specifically orientated to a Respiratory Rehabilitation Department (RRD). We therefore decided to develop a specific RRD-oriented HIS within our Medical Center (Tradate Medical Center of Rehabilitation, Salvatore Maugeri Foundation, Care and Research Institute, Varese, Italy), with the guidance of the Hospital Bioiengineering Department.

The aim of this paper is to describe the realization of this CPR for OP and IP Units of our RRD and to assess its efficacy in terms of the fundamental objectives mentioned above.

Realization of the project

Hardware and software structure

Computer system management and software development are administered locally by the Bioengineering Department staff. The whole HIS is

based on an Ethernet Local Area Network, TCP/IP communication protocol, and client/server architecture with UNIX server connected to over 30 DOS personal computers (PC). Seven workstations are located in the RRD. A relational Database Management System (Informix DBMS SE 5.0) with Standard Query Language (SQL) was used. The associated Fourth Generation Language (4GL) was used for applications development. Software engineering models and tools (Entity-Relationship model, "System Architect" CASE package) was used for the database design [9, 10]. With HIS being a multicentred project, effective co-operation is maintained with the other centres involved in the project (Veruno, Montescano and Pavia Medical Centers).

Data analysis and coding

Analysis was carried out by the Hospital Bioengineering Department staff in co-operation with local experts. The coding of all variables was agreed locally, except for acceptance and discharge diagnosis, which were coded according to the IXth version of the International Classification of Diseases (ICD-9). Information to be collected and fields to be coded were determined during regular meetings with RRD staff, both before and after the first installation.

Health-care quality improvement

Integration of patient information within the Department and on a large scale throughout the Centre. Patient administrative data (name, sex, birthdate, residence, citizenship, marital status, profession, admission date, admission ward, *etc.*) have been stored on computer since the Centre was opened in 1989. Until 1993, there was a stand-alone version of administrative procedure. Since July 1993, the demographic core (more than 10,000 items) has been shared by all HIS modules on a network database. Each patient is uniquely identified by a code number. All patient encounters with the Medical Centre and all associated documents are linked to this identification code. The system is password protected but an authorized user at a workstation anywhere on the health-care network has the ability to interrogate the historical referrals database on the network.

Definition of a well-focused and standardized (specifically for Respiratory Rehabilitation aspects) anamnestic, physical and admission data set for OP and IP Units. The database was modelled on the basis of expert advice and knowledge gleaned from the literature [11], without following any specific standard. Conceptual models for the clinical history, physical and admission course were purposely designed (table 1). The number of OP examinations officially stored in the database at present is 1,251, and that of IP clinical admission cards 650. As demonstrated by the low filling percentages reported in table 2, in the OP Unit a full and detailed data collection is seldom carried out due to a lack of time, whereas in the IP unit data filling is more thorough. The desired anamnestic link from OP toward IP is, therefore, at present limited. The information flow from the IP to OP unit and between two subsequent admissions is, on the contrary, effective and appreciated.

Direct physician use of the computer (direct entry). In the OP Unit, computerized data is fed directly into the PC by the physician. In the ward, there is a mixed approach; sometimes, whilst seeing a patient, data is fed into the PC in a workstation-equipped room, at other times doctors take notes and transfer them later into the PC. In either case, data input is personally managed by physicians.

Temporal integration of patient information. With readmissions being particularly numerous in a Rehabilitation Department (38% of total admissions), two features were important for the OP and IP Units: an automatic anamnestic link; and an on-line consultation of the patient's clinical history. An automatic anamnestic link between IP Unit admissions, cards of OP and IP Units, admissions and subsequent examinations in the OP Unit, was implemented as described below.

During patient reception, the system checks for the existence of previous anamnestic data. If a previous record exists, the system automatically duplicates the most recently collected data to form the basis of the new anamnestic survey. This enables the physician to evaluate the integrity of the copied data and modify any errors, or to update it with more recent information and, at the same time, leave the previous anamnestic data unmodified. Information pertaining to the current admission will become anamnestic data in a following admission or OP examination. Every time a patient is readmitted to the Department, the physician has rapid access to comprehensive information about patient anamnestic data from the previous anamnestic update. The physician can also consult on-line patient referrals, if produced by a terminal connected to the system. Once the patient's name is selected from the central demographic core, all events linked to the unique patient identification code are retrieved, temporarily sorted and displayed to the physician for consultation.

Legibility of documents and standardization improvement. Four types of documents are produced: OP examination reports; anamnestic data reports; physical examination reports; and discharge letters. The OP examination report is a short document given to the patient for his family doctor; it details therapy and thoracic examination results which are transferred from previously compiled physical examination forms together with a short textual synthesis written, with a word processor, by the physician.

More extensive are the anamnestic and physical examination documents. Using an appropriately built data dictionary, information gathered on data forms is translated into a pseudonatural language; in this way, legibility, synthesis and translation flexibility to the user's preferences are attained.

The discharge letter is written by means of a word processor, using a simple template prefilled

Table 1. – Clinical history and physical examination

Pneumological clinical history

Personal anamnesis
- School history*
- Notes

Working anamnesis
- Working activity
- Starting date
- Ending date
- Risk factors*
- Notes

Familial anamnesis
- Familial relationship
- Pathology*
- Deaths
- Notes

Physiological anamnesis
- Drug side-effects
- Drug name
- Drug category*
- Reaction
- Notes
- Sleep*
- Nutrition*
- Drinking habits*
- Smoking habits
  - Cigarettes·day^{-1}
  - From the age of
  - For how many years
  - Date of stopping
  - Pack-yrs
- Digestion*
- Abdomen*
- Urine output*
- Birth*
- Breast-feeding*
- APGAR score*
- Menarche
- Notes

Remote pathological anamnesis
- Thoracic surgical operations
  - Operation type*
  - Date
  - Notes
- Nonthoracic surgical operations
  - Operation type
  - Date
  - Notes
- Nonrespiratory pathologies
  - Pathology*
  - First diagnosis date
  - Description
  - Notes
- Respiratory pathologies
  - Pathology*
  - First diagnosis date
  - Diagnostic examinations*
  - Notes
- Previous admissions
  - Hospital
  - Hospital number
  - Admission date
  - Discharge date
  - Discharge diagnosis
- Previous FKT cycles
  - FKT type*
  - Starting date
  - Ending date
  - Notes

Near pathologic anamnesis
- Respiratory symptoms profile
  - Dyspnoea*
  - Duration
  - Dyspnoea type*
  - Dyspnoea intensity*
  - Cough*
  - Duration
  - Cough type*
  - Cough intensity*
  - Expectoration*
  - Expectoration type*
  - Expectoration intensity*
  - Wheezing*
  - Wheezing type*
  - Wheezing intensity*
  - Chest tightness*
  - Chest tightness type*
  - Fever
  - Thoracic pain
  - Notes
- Nonrespiratory symptoms profile
  - Notes
- Therapy
  - Drug
  - Starting date
  - Ending date
  - Dose
  - Notes

Physical examination

General aspect
- General conditions*
- Sensorium*
- Lying position*
- Breath*
- Body characteristics
- Personal autonomy*
- Notes

Skin and mucous membrane
- Appearence*
- General state*
- Hydration*
- Subcutaneous*
- Notes

Lymph node system
- Status*
- Characteristics*
- Notes

Head, neck, eyes
- Normality*
- Notes

Thorax
- Inspection and palpation
  - Form*
  - Expansion*
  - FVT*
  - Breathing pattern*
- Percussion
  - Mobility of basis*
  - Percussion note*
- Auscultation*
- Notes

Heart
- Visible pulsation*
- Sounds*
- Rub*
- Cardiac murmur*
- Notes

Abdomen
- Appearance*
- Kidneys*
- Liver/spleen
  - Dimensions
  - Surface*
  - Consistency*
  - Margin
  - Painfulness*
- Notes

Circulatory system
- Radial pulse
- Notes
- Bruite*
- Notes
- Veins*
- Notes
- Oedema*
- Notes

Locomotory system
- Skeletal*
- Muscular*
- Notes

Nervous system
- Objective examination*
- Psychiatric disturbances*
- Notes

Conceptual schema for clinical history and physical examination. *: categorical attributes. Clinical history data collection was designed with the aim of providing support for research and auditing. Particular attention was paid to respiratory paragraphs (thoracic surgery, respiratory pathologies and respiratory symptoms). An appropriately designed computerized patient record (CPR) can be a useful tool for retrospective studies involving data screening, where it is extremely important to identify clear classification of patient clinical data not easily obtainable through other financially-orientated CPR. FKT: physiokinesis therapy; FVT: vocal tactile quiver; APGAR: American Pediatric Gross Assessment Record.

with admission data (including patient's name, card number, age, sex) and reporting the main paragraphs to be considered.

Enhancement of health-care personnel productivity and cost reduction of the health-care delivery

User involvement, support and training. During the data analysis, a single physician was involved with the daily consultation, but regular meetings were scheduled to verify specifications with the entire RRD staff. Paper forms and application prototypes were shown at an early stage to the final users, in order to facilitate the final acceptance of the system.

Careful user-training was carried out during the initial period of application. The presence of the in-house Bioengineering Department made continuous

Table 2. – Filling percentages of single clinical items of anamnesis and physical examination in the In-patient (IP) and Out-patient (OP) Units

Clinical items	IP Unit Filling %	OP Unit Filling %
Clinical history		
School history and personal autonomy	98	18
Working activities and risk factors	82	18
Familiarity	46	7
Sleeping, nutritional, drinking and smoking habits	98	23
Drug side-effects	21	6
Nonthoracic surgery	63	13
Thoracic surgery	91	0.6
Respiratory Diseases	79	39
Nonrespiratory diseases	41	9
Previous admissions	77	31
Previous physiokinesistherapy	13	5
Respiratory symptoms	97	52
Nonrespiratory symptoms	94	13
Therapy	85	62
Physical examination		
General aspect	96	5
Skin	96	3
Head	97	3
Neck	94	3
Thorax	96	48
Heart	96	4
Abdomen	96	3
Circulatory system	94	3
Locomotory system	90	3
Nervous system	93	9

and punctual support possible. They were also readily available to provide assistance to the physician. Such user support gave vital feedback and suggested numerous software modifications.

Easy-to-use software package. A menu-driven data collection package was implemented, with textual interface, designed in such a way so that input results as quickly as possible. Most variables are inserted by code (a pop-up menu listing possible choices is always available). Where appropriate, the variables are preinitialized with default values, which need to be modified only for pathological cases. In the case of "normal frames", it is necessary for the physician to confirm the default settings. Although data entry (*via* data forms) is intended to standardize data input, the user is not obliged to adhere rigidly to this feature. It is possible to select clinical items in an order best suited to the individual situation. Unfortunately, the textual menu-driven interface is not always effective for quick and appropriate CPR consultation. At this point in time, we are migrating toward a more user-friendly interface, developing procedures with a graphical front-end under MS-Windows.

Physician and nurse support. In order to compensate for the time required to enter data in the computer system, we tried to maximize the benefits for physicians and nurses whilst performing clerical duties. The framework for discharge, clinical and referral letters is produced from the database and then transferred to a word-processing application for final editing and printing. In particular, anamnestic, physical and admission documents are fully generated from the database. On the ward, the physician compiles discharge sheets (reporting discharge diagnosis, main diagnostic procedures and discharge modality) on the computer using an on-line help function reporting ICD-9 codes and drawing patient examination lists from the CPR. This further improves the quality of administrative statistics, eliminating possible errors of correspondence between descriptive information and their codes, or date mismatching. Appointments are scheduled on a computerized booking diary and the availability of other simple features, such as label-printing, monthly summaries of activities and lists, of patients admitted, increase departmental secretarial efficiency.

Research support

Identification and coding of clinical variables needed to support protocols and general statistical analysis. Anamnestic data collection, as described earlier, was designed with the aim of providing support for research and audit purposes. Particular attention was paid to respiratory paragraphs (thoracic surgery, respiratory pathologies and respiratory symptoms). An appropriately designed CPR can be a useful tool for retrospective studies involving data screening, where it is extremely important to identify clear classification criteria and reduce confounders [12]. In fact, a number of research studies involve, as a first step, the recruitment of subjects with specific features, in order to meet the *a priori* aims by the investigator. Such prospective recruitment is often time-consuming and difficult, depending on the availability of IP and/or OP data, which have to be individually checked for the required features by the investigator or by other physicians, who have different responsibilities and interests within the collaboration. A retrospective recruitment is difficult also, because it is not easy to check multiple criteria on paper charts.

In order to provide a clearer understanding of the facilities of the CPR, let us consider a hypothetical study to evaluate gas exchange during exercise in asthmatic subjects. Data are required from a group of subjects having the following features: age 18–40 yrs; previous diagnosis of bronchial asthma; no other diseases; already tested with a methacholine bronchial challenge; nonsmokers; no occupational exposure to inhaled noxae; body weight within ±20% of the ideal weight; living in an area with low air pollution. The sample size has been previously fixed at 30 subjects. Currently, the total population of OP and IP with asthma recorded in the remote pathological history is 505. Using the CPR, 50 subjects fitting the above criteria can be obtained, which would enable recruitment of 30 patients either by telephone or letter.

Easy and quick data retrieval from central database for statistical analysis. At the moment this feature remains to be implemented. Data retrieval from the central database for statistical analysis is managed by the in-house Bioengineering Department.

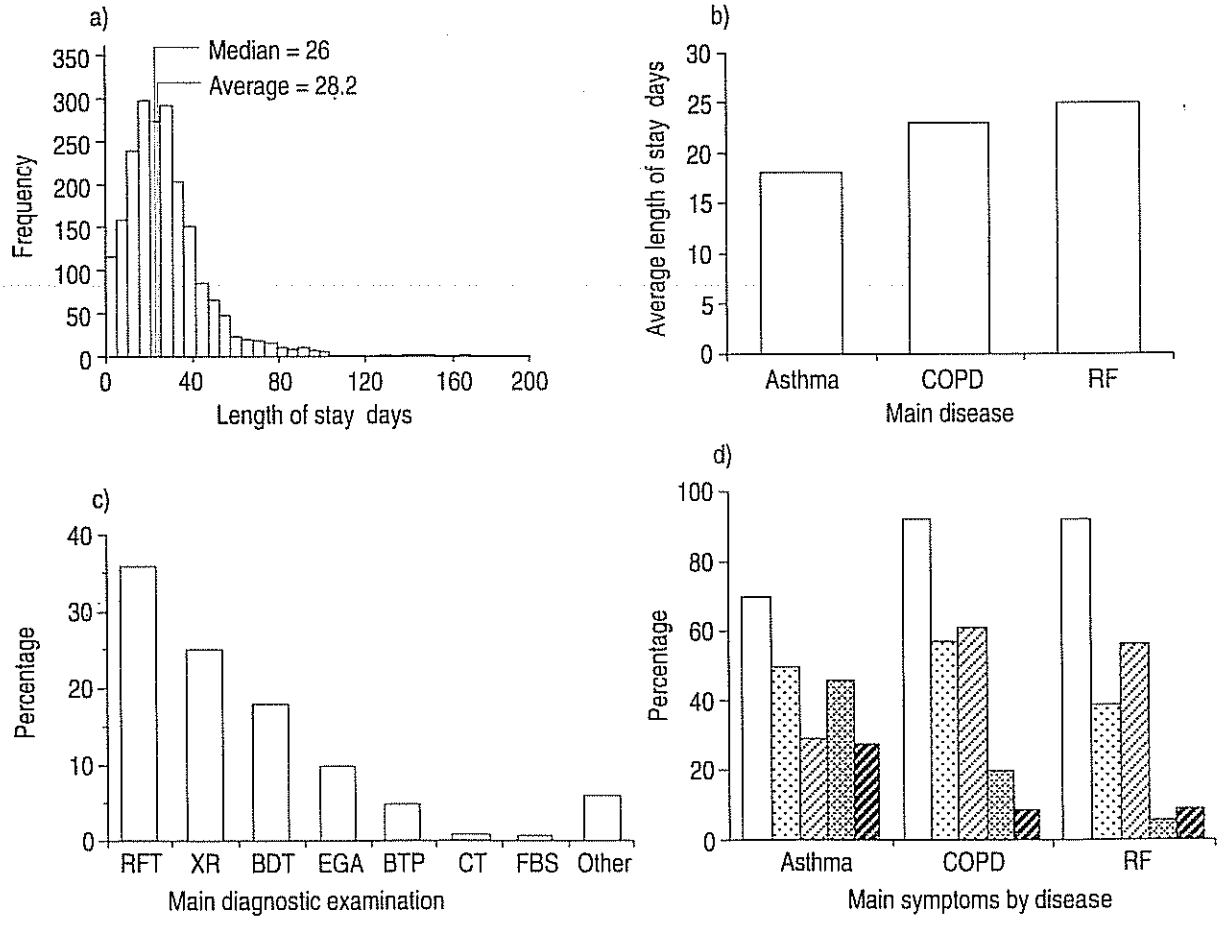

Fig. 1. – Aggregated views of administrative and clinical data from Respiratory Rehabilitation Department (RRD) patients. a) Distribution of the length of stay in RRD during 1994; b) average length of stay in relation to main diseases of patient admitted to the RRD during 1994; c) main diagnostic examinations prescribed by family doctors to diagnose asthma (from remote pathological anamnesis); d) distribution of main symptoms by disease (from recent pathological anamnesis). COPD: chronic obstructive pulmonary disease; RF: respiratory failure; RFT: respiratory function test; XR: chest radiography; BDT: bronchodilation test; EGA: Emogasanalysis; BTP: bronchostimulation test; CT: computerized tomography; FBS: fiberoptic bronchostimulation. ▭: dyspnoea; ▭: cough; ▨: smear; ▩: wheezing; ▨: breathing difficulty.

Accommodation of future developments, policy, management and finance

The CPR is easily able to give useful administrative information about RRD from routinely collected data on flow of patients, length of stay, type of population admitted, *etc.* (fig. 1a and b), or particular views about patient clinical data not easily obtainable from other financially-orientated CPR (fig. 1c and d). This information is important for the planning and management of RRD activities and will become strategic for the competitive health-care system of the future.

Discussion

In this paper, we have described our experience in developing a computerized patient record for a Respiratory Rehabilitation Department. Following recommendations in the literature, we implemented several specific features in order to pursue generical objectives, such as health-care quality, personnel productivity enhancement, research and audit support. Some of these features are of a general purpose type, whereas others, for example the development of a clinical database, are specific to a Respiratory Rehabilitation Department.

Although quality is difficult to measure, we believe that patient data centralization, data collection standardization, direct use of computer, patient temporal data integration and computerized document production have resulted in an improvement of health-care quality. It is easier for clinicians to follow the patient rehabilitation process, both in the spatial dimension (patient data integration within the Department and throughout the Centre) and in the temporal dimension (patient clinical history chronologically computerized). Hospital management has faster and better access to information for administrative statistics and resource auditing. Our experience has shown, however, that in the OP Unit faults caused by lack of time make the comprehensive employment of computerized data collection difficult (table 2), though it must be stated that these difficulties were not induced by introduction of the CPR *per se*. All the same, even if only in a partial way, the computerized procedure is systematically used for all recording of OP examination.

The RRD clinical database has evolved naturally from the environment in which it operates: it was the result of considerable co-operation between engineers and physicians to gather and incorporate expert respiratory knowledge. This approach distinguishes our CPRs from the majority of current CPRs, which are mostly financially orientated and not ap-propriate to cater for medical effectiveness and research. It will also permit the implementation of many poten-

many potential decision supports that could aid decision-making. Unfortunately, the HIS project is still in progress and some important units, such as laboratory analysis, are not yet linked to the HIS or, at present, collect only the textual referrals without detailed gathering of variables (Respiratory Physiopathology Unit). The patient clinical history is, therefore, incomplete and the potential research outcome limited.

The computer system is regularly used by the entire RRD staff involved in patient care service; this surely results in increased departmental secretarial efficiency and health-care personnel productivity. Nevertheless, as described elsewhere [7], the CPR does not reduce physician time requirements by a substantial degree and some benefits, *e.g.* research and audit support, will become apparent only in the long-term.

Finally, the effect of the CPR on the reduction of health-care service administrative costs was not extensively studied. Other authors [5] have estimated that it takes 3 yrs before the benefits of a system outweigh the costs, so it would be premature to attempt to evaluate the RRD computerized system from this point of view.

In conclusion, our implementation of a computerized patient record seems a good way to provide better health-care and to follow the rehabilitation process of Respiratory Rehabilitation Department patients in a more comprehensive way. Nevertheless, despite all the benefits described, additional studies are needed to produce more scientific evidence to support and justify its use.

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Il porto di Napoli