Clinical practice

Graphical summary of patient status

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Patient records accrue handwritten notes, flowsheets, forms, printouts, lab-slips, orders, journal reprints, and an occasional identification tag from a transfused unit of blood or an implanted prosthesis. The traditional medical record serves administrative, regulatory, financial, legal, and clinical needs. Being largely a device for storage, the record is not designed with patient care in mind. Physicians and nurses must sort through such "data dumps" to see what has happened to their patients. Medical records will soon be computerised,[1,2] making them more legible but hardly more comprehensible. Data are just as easily lost in pages of printout as in tangles of handwriting.

The Institute of Medicine's Committee on Improving the Medical Record lists fifty-six uses, from "foster continuity of care" and "provide the basis for utilization review" to "manage costs" and "plan marketing strategy".[3] It is convenient for medical personnel to record notes, orders, and observations in a record: any pen and space will do. The traditional record is such an easy device to use that it has proved difficult to replace. Most proposed changes require more effort on the part of those writing notes and issuing orders.[4]

Case reports, dating back to antiquity, led eventually to modern medical records.[5] Detailed notes resembling the record appeared in hospitals in the 1900s.[6] By the 1950s, records were being standardised. In the 1960s, the hospital record became "a basis for planning [individual] patient care",[7] and the Joint Commission on Accreditation of Hospitals began to evaluate a record on "whether or not it contains sufficient recorded information to justify the diagnosis and warrant the treatment and end results".[8] Thus hospital records before 1900 focused mainly on the disease process or organisational issues, but by 1950 on the medical process.

The problem-oriented record[9-11] was introduced in the 1960s when Weed recommended "a complete list of all the patient's problems . . . a dynamic table of contents of the patient's chart".[9] Weed's proposal emphasises individual problems and the subdivision of information into subjective aspects, objective aspects, assessment, and planning. Although the wisdom of the problem-oriented approach is debated,[12,13] it was the last major revision of the traditional medical record.

Short, summary records have been tried in outpatient clinics. Two studies indicated that doctors work from just a small portion of a traditional record. Provided with a summary, physicians requested full records in only 26% of rheumatology clinic visits.[14] Average hospital stays were 1 week shorter during the second year that summaries were provided to cardiac, pulmonary, and renal clinics.[15] Neither study provided computer-generated reminders or computerised monitoring of clinical management.[16,17]

Two non-text methods of presenting patient data are anatomically based displays and flowsheets. Anatomical displays occasionally appear in traditional records: surgical scars, new wounds, the outline of the liver, &c, are drawn on a rough sketch of the body. One could map laboratory values over appropriate organs: alkaline phosphatase over liver and gallbladder, urinanalysis over bladder or kidney. Colour might call attention to organs at risk,[18] but where are we to write, in a meaningful way, systemic findings such as temperature or white-blood-cell (WBC) count, and how are we to convey time on an anatomical display?[19]

Often used in intensive-care units, flowsheets tabulate patient information over time and can be computer-generated.[20,21] Since a flurry of activity produces a flurry of columns, many flowsheets have an arbitrary time-scale based on the occurrence of events and measurements rather than on regular intervals. In addition, values are often unchanged from event to event, leading to repetitious detail.

It is hard to do anything with a traditional medical record besides write in it. Records are bulky, difficult to file, hard to retrieve, and often illegible. By contrast with the acronyms WYSIWYG (what you see is what you get) and WORM (write once read many), the acronym for the medical record might well be WORN (write once read never).

We propose a graphical summary of patient status to overlay the traditional medical record with a report primarily to serve medical care. Numerical data are plotted to reveal the course of an illness and response to treatment. The most recent values are shown numerically as well as graphically. Notes and stamp-sized medical images are included in a form appropriate for high-resolution computer display or laser-printed page. The consequence is a richly detailed, one-page summary of patient status.

A medical history need not be solely a prose account of the life and illness of a patient. A graphic breaks the limitations of text, recasting records as Weed did some 25 years ago.[3,4] A graphical summary does not replace the traditional record any more than a map replaces a telephone directory. Similar to a map, a graphic provides a view of illness in a patient, letting clinicians see how various findings and treatments relate to each other.

Design of a graphical summary

Our display of patient status uses small repeated graphs with identical formats for ease of reading (figure 1).[22-25] For the example of serum glucose no tests were done during the 12 months before admission, although many readings were made more than 1 year earlier. Information from the traditional record for this patient was abstracted and entered manually. The graphics were prepared with commercially available hardware and software; customised software (in Common Lisp) was used to scale the data.

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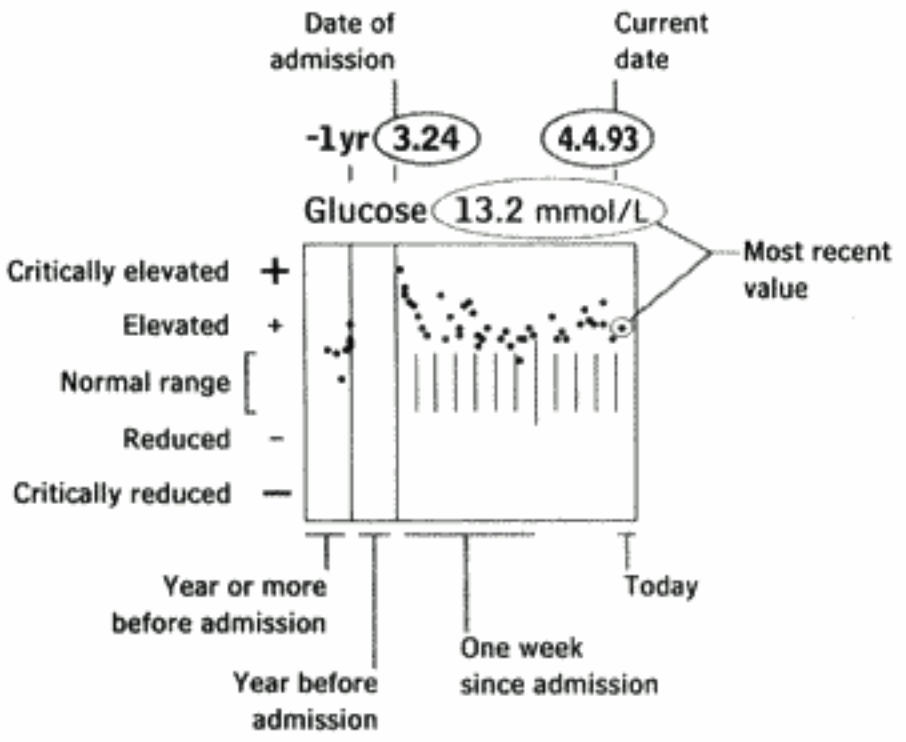

Figure 1: **The basic graph**

American date-format used.

For graphical summary, a non-linear time-scale compresses years of data into a context for assessing recent trends. Findings and treatments are individually scaled to allow a uniform vertical axis. The customised software includes numerical tables that specify the scale for each finding and treatment. These tables are based on laboratory reference values, recommended drug doses, and clinical judgment. Use of scaled values simplifies interpretation: gross vertical displacement corresponds to clinical significance. Within each range (normal, elevated, reduced, &c) the vertical axis is linear to reveal trends. The most recent value is plotted (the rightmost dot in the graphic) and printed above each graph. For medications, a horizontal line indicates the total of individual doses received during 1 day.

The column on the right (figure 2) presents short notes relevant to clinical care, with the most recent note at the top. Staff can flag the relevant portions of their chart notes for inclusion, or objective and subjective parts of Weed's classification (subjective and objective aspects, assessment, and planning) can be included automatically. Date and time are placed with the signature at the end of each note. The combination of initials and professional degree is likely to identify the writer uniquely.

A compact and legible typeface, Bitstream Bell Centennial,[26] is used. This typeface is designed for telephone directories, and does particularly well for mixtures of words and numbers.[27] The typography has been specified.[28] Figures 1 and 2 were composed with Adobe Illustrator.

Example of graphical summary

Figure 2 shows the complete graphical summary. This case was chosen for its complexity, long history (with data available), and combination of psychiatric and medical illnesses. The patient had been treated for manic-depressive disease for more than 30 years; she was admitted on March 24, 1993, for fever, cough, and worsening psychiatric symptoms. To place the current admission in context, values from the year before admission are displayed on the scale between −1 year and 3.24 (American date format); another 29 years are condensed to the left of −1 year. Figure 2 includes the complete data from a 24 by 484 flowsheet (11 616 cells) with 1786 values on ten pages.

On admission, WBC count, temperature, and respiration are elevated. However, WBC does not appear significantly increased over previous values, which were probably caused by lithium carbonate therapy. Treatment with cefuroxime and clindamycin led to a reduction in temperature. WBC count and temperature rebounded briefly when antibiotics were stopped; the note of April 2, 1993, suggests that contralateral atelectasis might be the reason. Chest radiographs, shown in miniature, suggest a right lower-lobe pneumonia at admission, with some improvement visible at April 1, 1993.

Diabetes is evident from the increased serum glucose which responded to insulin. Raised glucose had been noted over a year ago, but the admission value was even higher. Treatment was switched to oral glibenclamide on March 29, 1993. The notes also report that the patient vomited on April 2, 1993. Nonetheless, all the abnormalities shown by the plots were stabilising and the patient was discharged on April 4, 1993.

Serum calcium was increased but responded promptly to rehydration and cessation of lithium carbonate. Indeed, all psychiatric medications except haloperidol were stopped after the third day.

Psychiatric status was rated in terms of psychosis and mood. Psychosis and delirium were rated from 0 (normal) to 3 (florid hallucinations). Mood could range from −3 (severely depressed) to 0 (normal) to 3 (floridly manic). Psychiatric scales, such as the brief psychiatric rating scale, Folstein mini-mental state examination, and Hamilton depression rating scale, could also be displayed if they had been used in this case.[29] As figure 2 shows, the patient rapidly became psychotic after admission, more so than in the previous year. The disturbance lessened by the fourth day and resolved by the eighth day. During most of the hospital stay, no comments were made about mood. Rapid onset and resolution suggest delirium rather than exacerbation of manic-depression.

Figure 2 compresses years of clinical information onto one page and also offers enough detail to show, for example, that only five different respiratory rates were ever recorded: 16, 20, 24, and 28, and 18 breaths per minute. By showing temporal relations between treatment and findings, graphical summaries reveal evidence directly relevant to the clinician. For the patient in figure 2, the hope was that antibiotics for pneumonia, insulin for diabetes, and intravenous fluid to treat hypercalcaemia and dehydration would correct her acute decompensation and allow transition to oral treatment for diabetes. Placement of the treatment plots just below the appropriate plots of clinical findings emphasises their connection and validates the management plan.

Extending the graphical summary

Graphics can also show more complex clinical relations. A scatterplot of psychosis against serum lithium would test the hypothesis that this patient required a level greater than 1·0 mmol/L to provide adequate protection. For a patient with Parkinson's disease, a three-dimensional plot with rigidity on the z-axis, daily dose of anticholinergic medication on the x-axis, and daily dose of levodopa on the y-axis could validate the need for two-drug therapy and help to find the minimum effective doses. Connection of successive points in such a plot may help to show the course of disease in relation to the two-drug therapy. For the convenience of specialists, customised selections of

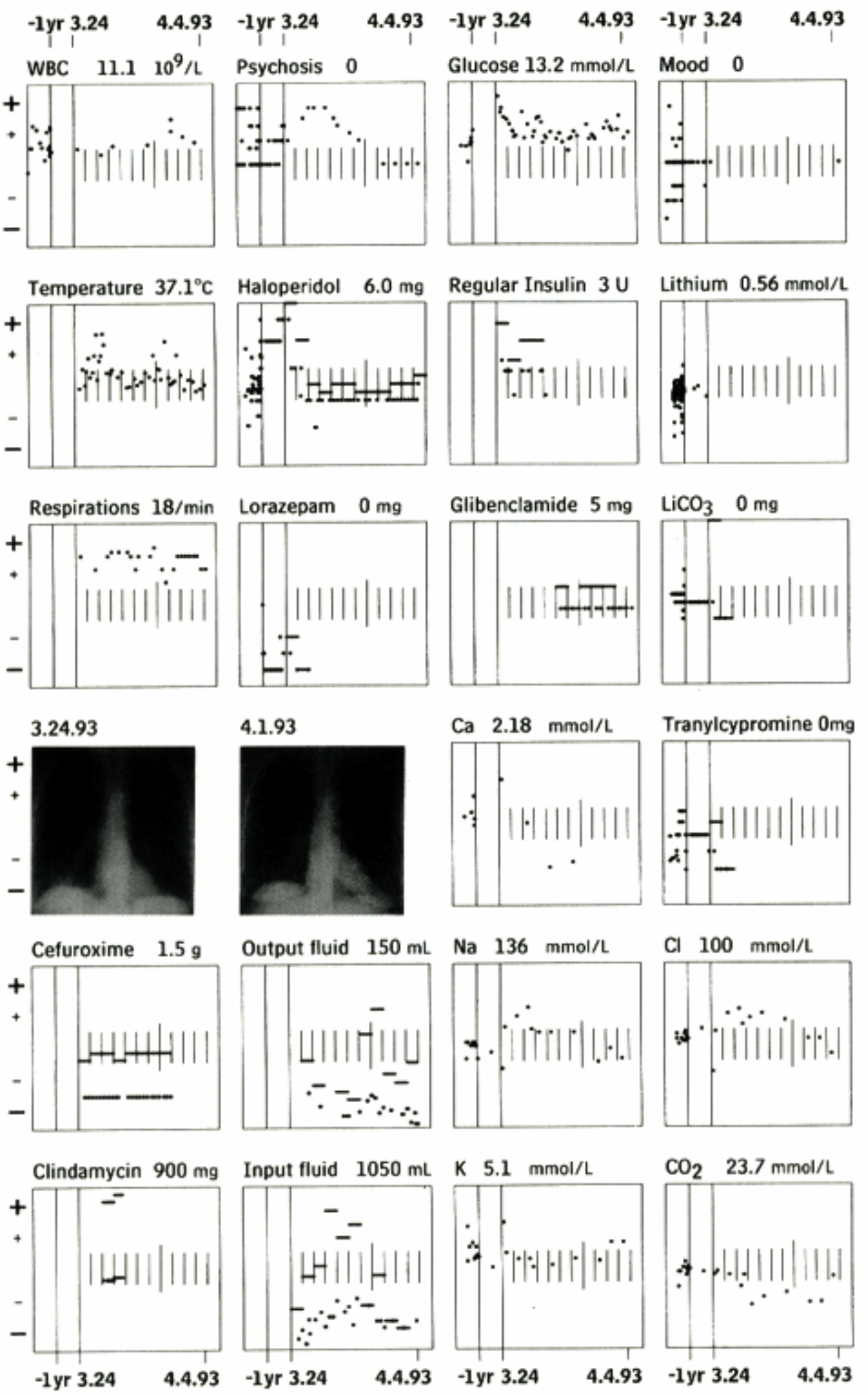

Figure 2: **Graphical summary of patient status**

Notes on right show initials and professional qualification (MD = medical doctor, RN = registered nurse), time, and date (American format). — = period of dosing.

measurements and treatments are possible. Different time scales and vertical scales would be appropriate for cyclical syndromes (eg, malaria) or slowly changing findings (eg, tumour markers).

Full-page computer displays can show figure 2 as printed here. Although providing the same information as in figure 2, full-page screens are coarser because of larger pixel size compared with the laser-printer's dot. Computer displays

can be updated in real-time and can also allow users to interact with the data by selecting and modifying elements of the graphic.

Conclusion

Our graphical summary of patient status maps findings and treatments over time. It is a high-resolution display that invites the viewer to assess relations between findings and treatments, and allows for consideration of alternative diagnostic and management strategies. Instead of a 5 cm thick record, a single page reveals the data graphically. Graphical summaries will be especially useful during case conferences or teaching exercises; all the participants, each with a copy, can review the history and treatment.

Medical computer systems will soon be able to print a fresh summary for each patient every day. Our proposal for a graphical summary should encourage doctors and nurses to reshape, perhaps re-invent, the medical record before computer programmers cast institutional convenience into silicon. Legal and organisational demands for detailed information will not disappear, but these demands need not compromise clinical needs for accessible patient information.

We thank Inge Druckrey and Bonnie Scranton for design advice and Dr Robert Byck, Dr Jeffrey I Clyman, Dr Thomas P Duffy, Dr Alvan R Feinstein, Dr Robert H Gifford, Dr Selby C Jacobs, Dr Kathleen M Kim, Dr Perry L Miller, Dr Edward R Powsner, Dr Howard M Spiro, and Dr Virginia J Tufte for their critiques of this manuscript.

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