

Graphical Display of Clinical and Laboratory Data Using a Desktop
Computer Interfaced with a Hospital Information System

J. J. Cimino, P. J. Munson, T. Lewis, and D. Rodbard

Biophysical Endocrinology Section, Endocrinology and Reproduction
Research Branch, NICHD, and Office of Clinical and Management Systems,
Clinical Center, National Institutes of Health Bethesda, Maryland 20205

Abstract

A desktop computer has been used successfully to provide high quality graphical display of clinical data (e.g. vital signs) and laboratory data in conjunction with a hospital information system (Technicon MIS). This approach offers several advantages: 1) ease and speed of operation for physician with a pushbutton, menu-driven program; 2) ease and speed of system development; 3) versatility and flexibility. This approach also encourages use of the computer by physicians for a wide range of other applications.

Introduction

Hospital information systems often provide for storage and retrieval of clinical and laboratory data, but generally do not provide a longitudinal display of several variables, and/or ready accessibility of hardcopy of such graphs. Graphical display of clinical lab data has been described in a prototype system developed by others using a PLATO terminal communicating with a laboratory computer (1). However, at almost all institutions, use of hand drawn graphs has been required, or else (more commonly), the physician has sacrificed the advantages of such displays.

Here we describe one attempt to remedy this deficiency: The Technicon MIS hospital information system communicates with a small desktop computer (Hewlett Packard, HP9845A, with 64 K bytes of memory, equipped with a built-in thermal printer, two tape cassette drives, clock, and RS232 interface). We avoided the use of discs or flatbed plotter to minimize expense and complexity. Program development was facilitated using extended BASIC on this small machine.

"Patient Information Graphics System" Features:

- 1) The program is "friendly" and virtually self-teaching. The program is loaded automatically when the graphics device is turned on and provides prompts for user entries;
- 2) Special function keys are used to select items from several 'menus'; no typing is required of the user;
- 3) One may display 1, 2, 3 or 4 graphs on the screen simultaneously, or two variables may be superimposed with different line-types;
- 4) Linear or logarithmic scaling of the vertical axis is selected by pushbutton. The horizontal axis displays time in minutes, hours or days, as appropriate;
- 5) Optimal plotting limits and increments are provided automatically, although the user can override these, e.g. to expand a region of special interest. Display line and point type may be selected by the user if he desires;



Figure 1. P.I.G.S. system in operation. Left: HP9845 desk-top, right: MIS Video Matrix Terminal, connected to PIGS via RS232C interface.

- 6) Data may be entered from MIS, from Keyboard, or from tape. Up to 1000 data points (date, time, value) and/or up to 30 data lists may be used for any one series of plots;
- 7) Data can be stored on tape cassettes for further analyses by other programs or for replotting after additional data become available;
- 8) Speed and ease of operation provide high physician acceptance;
- 9) During operation, the keyboard is "locked", so that accidental or incorrect entries by the user will not affect program execution;
- 10) One can easily superimpose data from the subject of interest on the normal ranges (stored on tape cassette);
- 11) A printed summary of all data can be obtained, sorted chronologically or by data item.

Program and System Design

The HP9845 computer receives data from a MIS Video Matrix Terminal via a RS232 connector at 2400 baud (Fig. 1). A data initialization routine parses these data, and stores them on the system tape. This routine also permits entry of data from keyboard or from tape, and storage of data on tape. The "Menu" as it appears on the screen is shown in Fig. 2A.

Patient Information Graphics System - Data Initialization 04/07/81	
Key	Function
0	- ACCEPT data from the MIS
1	- READ a data file from TAPE drive T14
2	- TYPE in patient DATA from keyboard
3	- DISPLAY/DELETE current data lists
4	- STORE all current data lists onto TAPE drive T14
5	- Display current PATIENT name and number
15	- Go to GRAPHICS routines

Fig. 2A

The graphics routine is then loaded and provides the options shown in Fig. 2B. Graphs are displayed and printed in a variety of formats. Graphs may be edited using the "Menu" shown in Fig. 2C. The code comprises approximately 1700 lines and occupies approximately 20K bytes, allowing about 40K for data storage.

Program listings, documentation, sample output, and user's guide will be made available on request.

Patient Information Graphics System - Main Menu 04/07/81	
Key	Function
0	- PLOT ALL current data lists
1	- SELECT data lists for plotting
2	- PLOT SELECTED or previous data lists
3	- PLOT TWO selected data lists on same graph
4	- Print REPORT of all data lists sorted by DATA TYPE
5	- Print REPORT of all data lists sorted by DATE
6	- Display current PATIENT
7	- EDIT plotting specs for selected or previous data list
15	- RETURN to data initialization routine

Fig. 2B

Figure 2. Menus offered to user: A) Data initialization routine; B) Graphics Routine; C) Editing Sub-Routine for Graphics.

Patient Information Graphics System - Editing Menu 04/07/81	
Key	Function
0	- Change TITLE of data list
1	- Change UNITS LABEL of data list
2	- Set new FIRST DATE for plotting
3	- Set new LAST DATE for plotting
4	- Set new y-axis LOWER LIMIT
5	- Set new y-axis UPPER LIMIT
6	- Set new y-axis INTERVAL
7	- Change y-axis scaling (LINEAR-LOG)
8	- FORCE data to START at NEW DATE and time
9	- MATCH this data to another data list (to be selected)
14	- RESTORE all initial values
15	- RETURN to main menu

List title: Comp F Keto Norm Scaling: Linear
 First day: Jan 1, 1981 0:00AM
 Last day: Jan 3, 1981 0:00AM
 Lower limit: 0
 Upper limit: 50
 Y-axis interval: 10

Fig. 2C

Applications

Representative output is shown in Fig. 3A-E. These "graphics" are extremely useful in visualizing the course of therapy, especially in complicated cases, e.g. patients in intensive care units, patients receiving chemotherapy, patients with acute infectious diseases, and those receiving multiple forms of therapy, such as in the hospitalized patient with hypertension or with fluid and electrolyte problems. It is especially helpful in evaluating the results of endocrine provocative tests, e.g. Insulin Tolerance Tests, ACTH infusions, the metyrapone test, TRH, LHRH, TSH, HCG administration, and dehydration tests.

Discussion

The present system design has greatly facilitated program development. A large part of the programming could be done interactively

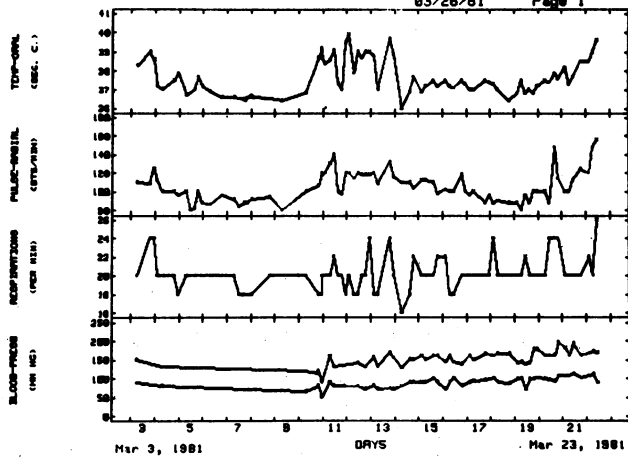


Fig. 3A

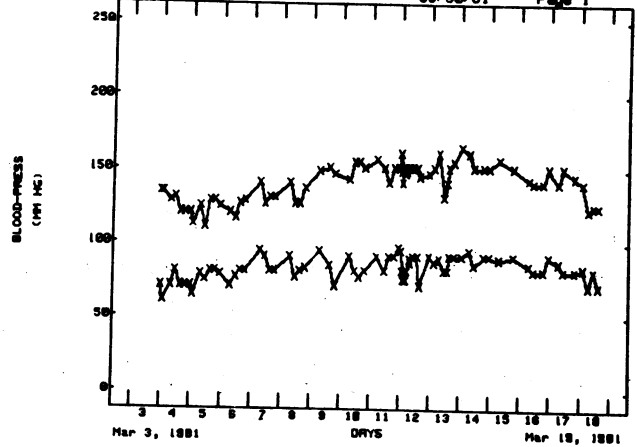


Fig. 3D

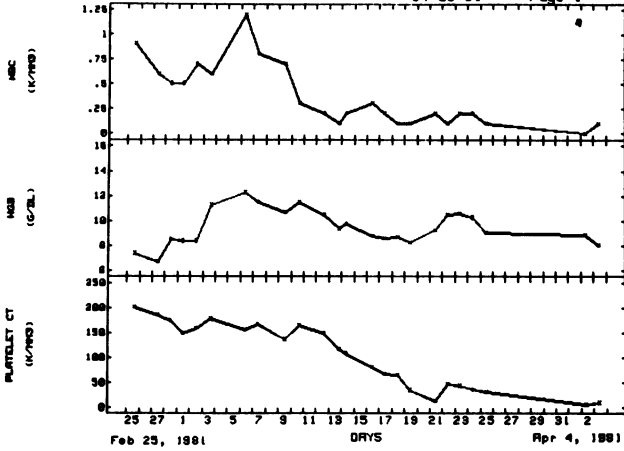


Fig. 3B

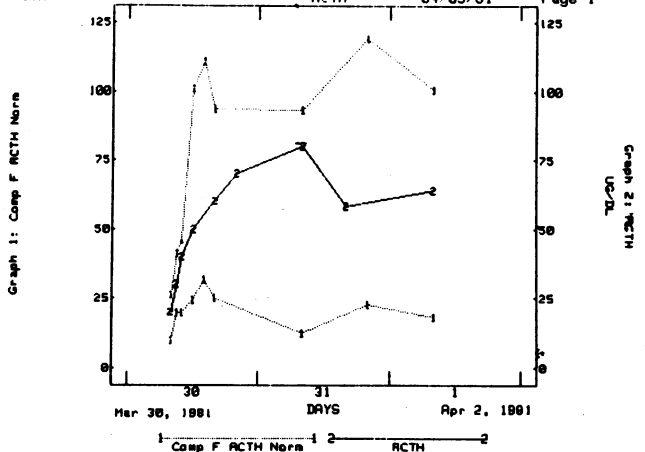


Fig. 3E

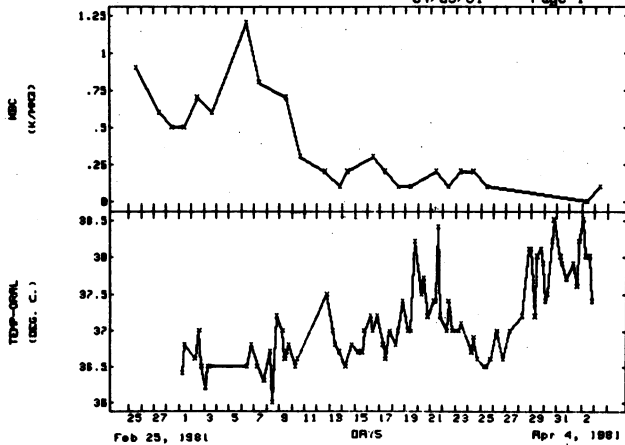


Fig. 3C

Figure 3. Representative Output: A) Display of four graphs (Temperature, Pulse, Respiration, Blood Pressure); B) Display of three curves (leukocyte count, hemoglobin, platelets); C) Display of two graphs (leukocyte count and temperature); D) Display of one dualentry variable (blood pressure); E) Display of two curves (patient data superimposed on normal ranges for plasma cortisol during ACTH infusion).

on the desk-top computer, without the complications of modifying the extremely large MIS system or its hardware configuration. As a result, the initial phase of program development was accomplished in three months. After the features have been optimized for any given nursing unit (which may vary considerably in a "research" hospital such as the NIH Clinical Center), the features would ideally be incorporated into the "central" MIS. However, having a small, quiet, friendly computer at the nursing station permits its use in a variety of other clinical applications. For example, we have implemented programs for analysis of radio-immunoassay and radioligand assay results, for calculation of free testosterone and estradiol (when total concentrations of steroids and binding proteins are known), for analysis of changes in linear growth velocity in response to growth hormone, thyroid, androgen or other endocrine therapy, for calculation of body surface area and drug doses in pediatrics, etc. Further, by providing a small computer at easily accessible sites within the hospital, we have encouraged many physicians to utilize the computer for other purposes. We believe that similar small systems should have considerable impact on the practical aspects of medical care while capturing data in a form useful for statistical analysis and performing a useful educational function.

References

- 1) Connelly, D.P., Lasky, L.C., Keller, R., and Moore S.A.: Graphical Representation of Clinical Laboratory Data., Proc. of 4th Annual Symposium on Computer Applications in Medical Care, November 1980, Washington, D.C., pp 1841-1848.

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