THE ROLE OF COMPUTER ASSISTED FLUID BALANCE IN CRITICAL CARE

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ABSTRACT
Computational, reporting, and data base management needs along with growth in sophistication have propelled the application of computers in medicine. These elements are satisfying specific clinical needs in the fluid balance program design that was undertaken. Significant potential exists for extending the computer's intervention by using available transducing techniques to obtain information that is currently manually derived. Thus, the design currently satisfies the goal of maximizing information while minimizing labor intensive overhead and will continue to evolve in that direction.

INTRODUCTION
Management of fluid balance, electrolyte levels, and nutritional status can be among the more important aspects of critical care. Imbalances can occur as a result of illness, diarrhea, vomiting, nasogastric suctioning, hemorrhaging, or surgical procedures. Under such circumstances, and especially in patients who are unable to eat, it is frequently necessary to anticipate and correct deficits and imbalances by administration of suitable replacement fluids.

At Hewlett-Packard we have developed in cooperation with the University of California at San Diego and Children's Hospital of Philadelphia a computer program to assist maintaining proper fluid balance. This program has been designed to run in the operating environment of the Hewlett-Packard 5600A Patient Monitoring Computer System.

PURPOSE OF COMPUTER INTERVENTION
In clinical practice usually only volume balances are recorded. It is a time consuming manual operation to calculate intake electrolytes, caloric consumption, and nutritional status. Thus, a significant contribution lies in making these determinations and the selection of suitable fluid therapy. Ancillary benefits include data retrieval that correlates useful information and medically significant reports replacing the nurses chart of intakes and outputs.

In order to maximize these contributions, the tools provided must be integrated into clinical care in a fashion amenable to user interaction.

DESIGN CRITERION
Intensive care units differ in their modality of care. Thus, the information each unit would be interested in maintaining and reviewing for intake/output varies. As a result, it was of paramount importance to design the subsystem to account for these variations. In general, the fundamental displays are constant while the information is user dependent.

The design was also undertaken to minimize the trauma a new user typically associates with the operation of a computer system. For example, help frames specific to the task a user is performing can be easily accessed.

CONVENTIONS
Military time is used. The entry time associated with a fluid entry is an integer hour. For example, an entry at 0620 is assumed to be for 0700. When the subsystem is accessed, time is handled automatically; alternatively, it can be modified by user. Volumes entered are assumed to be the amount which has been entered or measured since the last entry. These assumptions for time and volume are consistent with clinical practice.

OPERATIONAL ASPECTS
Entry. Entry of information is accomplished through interaction with the frames shown in Figures 1 thru 3. All frames are displayed on a CRT associated at bedside with a hand held keyboard or at central station with a full typewriter like keyboard for input. These keyboards feature use of specially engraved keys to facilitate interaction.
1) Fluids-A majority of all user input will occur on the sample frame depicted in Figure 1. The bouncing arrow (moved by entering ";line number") eliminates ambiguity by pointing to a function to be performed. Values entered are echoed at the bottom of the display and moved to the line with the arrow when the entry is terminated with "GO". For recall, the user can move the arrow to a previously entered line or utilize an erase key before the "GO" is depressed. The arrow will always move to the next vacant entry, or, if lines have been skipped, to the line from which it was moved. Entry of "STOP" is synonymous with no longer administering or measuring a fluid. This automatically deletes the fluid from the entry list after four hours. Note that the three previous hourly entries are recalled.

Since the system is aware of the compositional elements (constituents) in each fluid, the volume entered allows it to maintain a running total of these elements.

2) Selecting Fluids - The fluid entry list is "set-up" by selecting fluids from the list illustrated in Figure 2. Fluids can also be inserted in the entry list at any time.

3) Special Additives - The presence of special additives is illustrated in Figure 1 by the "+ADD (line 5) or a "+KCL" designation. KCL is specifically called out because it is by far the most frequently used additive. Thus, to circumvent the additional overhead required by Figure 3, a special mechanism for handling KCL was designed. This entails following the fluid entry with ";amount of KCL". For the general case, additive selection is shown in Figure 3. The bouncing arrow operates in the same way as previously described. The left hand side of the frame displays a list of possible additives while the right hand side displays constituent quantities. This tabulation includes the standard composition of the fluid and a total which is appropriately updated by the inclusion of additives.

Recall: Recall involves reviewing both entered and derived parameters and is accomplished through five frames. Three of these five recall frames are illustrated in Figure 4 through 5. The other two displays are essentially identical to Figures 1 and 3 but without the bouncing arrow. Inherent to this review mechanism is the ability to "page" sequentially to older and newer information relative to the page the user is viewing. This sequence of displays is ordered so the user can view a "table of contents" to select another frame; alternatively, a frame number may be entered for direct movement from one display to another.

Figure 4 illustrates condensation of information by category and time. The first three time columns correspond to eight hour shift ending times. As mentioned, electrolyte and nutritional summary information that were previously very difficult to maintain can be viewed in Figure 5. Finally, the daily summaries shown in Figure 6 allow the clinician to easily track long term trends.

Reports: Two reports will supplement the CRT information by providing hardcopies suitable for inclusion in the patient's chart. The first report spans 24 hours (3 shifts) and enumerates hourly entries similar to Figure 1 but using eight time columns. The second report actually entails the summary information presented in Figures 4 and 5 with weight calculations. These reports can be scheduled or produced on demand.

DISCUSSION RESULTS

The intake/output package described in another step in the integration of computers into clinical intensive care. Although computers have been used for many years in business and science, their incorporation into clinical medicine has been slow. This can be attributable to several reasons:

1) The scope of commercially available software packages has not been comprehensive enough to justify complete dependence on the computer system. Although several companies market clinical systems, not one has been successful in replacing the nurses chart. Thus, nurses may have to keep duplicate manual records and derive little benefit. The intake/output subsystem described is comprehensive enough so duplication is not necessary.

2) Commercially available software has tended to duplicate rather than extend clinical capabilities. Thus, for computer assisted intake/output, keeping track of volumes is not sufficient. The real benefit comes from the electrolyte and nutritional summaries it extends to users. This information is difficult and time consuming to obtain; yet, it is important to patient care.

3) Often, clinical systems have been viewed as a panacea. It is not sufficient to put it on. Commitments must be made by the staff and administration to use the system so maximum benefit can be derived. Training plans and protocols must be established, adhered to, and reviewed periodically for success.
SUMMARY

We have presented a paper on computer assisted fluid balance in clinical intensive care. The package by itself is very powerful and offers important information not readily available. It meets differences in care methodology likely to be encountered among hospitals. Care has been given to human engineering. Our hope is that this, coupled with other capabilities, will move computers one step closer to significant clinical contributions in critical care.

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FIGURE 1

I/O ENTRY
1. ID# 257-53-5978 GEORGE JARAGAGE
2. TIME 1800 30 AUG
3. WEIGHT(KG) 50.00 AT 0700 30 AUG

ENTRIES 0700 0800 0900 1000
-2 DS 1.4 NS 50 50 50
-3 100 40 100
5 KCL 50 100
7 KNO3 50 0
9 CH3 I-CLR 50 0
99 PUSH 'GO' TO STORE

FOR INSTRUCTIONS PUSH 1 GO PAGE 1 OF 1

FIGURE 3

BED 2A GEORGE JARAGAGE 06 JUL 1204

ADDITIVE SELECTION

AVAIL. AMOUNT COMPONENT TOTAL
1 IV NS0 0 MNS 0 NS0 0 NS
2 ORAL NS0 MNS MNS 0 NS0 0 NS
3 DS-0.4 NS0 0 MNS 0 NS0 0 NS
4 DS-0.4 NS0 0 0 NS0 NS0 NS
5 KNO3 0 0 0 0 0
7 KNO3 0 0 0 0 0
9 KNO3 0 0 0 0 0
10 CA GLUCON 0 MG NS0 0 NS0 0 NS
11 CA GLUCON 0 0 0 0 0
12 K ACETATE 0 0 0 0 0
13 MG04 0 0 0 0 0
14 MG04 0 0 0 0 0
99 'GO' TO STORE

FOR INSTRUCTIONS PUSH 1 GO PAGE 1 OF 1

FIGURE 5

BED 2A GEORGE JARAGAGE 06 JUL 1433

ELECTROLYTE/NUTRITIONAL SUMMARY - JUL 05

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FOR INSTRUCTIONS PUSH 1 GO PAGE 3 OF 4

FIGURE 6

BED 2A GEORGE JARAGAGE 06 JUL 1434

DAILY WEIGHT / VOLUME SUMMARY

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