Data Base for Stroke Rehabilitation Using Computerized English Text Discharge Summaries

BY PETER H. STERN, M.D.,* JAY C. LINCOLN,† AND MARILYN B. ROBINSON, R.N.‡

Abstract: A data processing system programmed in a terminal-oriented language called APL is described. This user-oriented system features the print-out of English text discharge summaries for patients treated in a stroke rehabilitation unit. The variables contained in the summaries are stored in the computer for statistical analysis, allowing continuous monitoring of the unit's activities. Seventy-eight percent of patients with moderate to severe hemiparesis were able to return home after an average length of stay of 44 days. The value of the described system is suggested for multicenter, cooperative studies on stroke.

Additional Key Words: cooperative study

statistical analysis

stroke unit

Introduction

The ever-increasing demands for documentation in health care provided the impetus to computerize medical records. Previous experience with a data processing system programmed in a terminal-oriented language called APL convinced us of the feasibility of computerizing discharge summaries, particularly for patients with disorders or conditions that can be described in a relatively finite number of variables.

The first computerized English text discharge summaries at Cornell University Medical Center (New York, New York) using the APL programming language were produced by the Department of Obstetrics and Gynecology for deliveries and abortions. The collected data were stored and used to generate statistical reports required by the Department of Health of New York City. At that time the authors of this program discerned the practicability and desirability of developing a general purpose program that would request, manipulate, store, and output data presented in a questionnaire format.

The work to be described began in March 1974, in an attempt to computerize discharge summaries of a 150-bed rehabilitation hospital, categorized in five distinct disability units. This paper is limited to the description of the system used for the Stroke Unit.

Methods

The computer system, APL/360(370), consists of a terminal incorporating a Selectric typewriter connected via ordinary telephone equipment to a remotely located central computer. It is a time-sharing system; that is, many terminals can be connected simultaneously to the central computer and each user has the APL system available to him in a conversational manner.

The new general purpose program, APG (A Program Generator), has unique features and power for a general purpose, user-oriented information system and does not require any special knowledge in mathematics or computer science. For our purposes, APG application consists of the following components: pre-programming, programming, operation, and analysis.

PRE-PROGRAMMING

In this phase a questionnaire-type discharge summary worksheet is constructed and sample prose is provided. This requires close rapport between the users, e.g., the physicians and the programmers. The worksheet is the device which determines the output for format, content, and prose of the discharge summary and the generation of statistical reports.

In this crucial phase the establishment of clearly defined objectives must precede any thought of employing a computerized data collection and analysis system. Figure 1 shows the stroke rehabilitation worksheet for the generation of discharge summaries. It consists of the customary questions arranged in segments covering the reason for hospitalization, pertinent history, pertinent physical, x-ray, and laboratory findings, and the course in hospital. Special emphasis is placed on the functional status, condition on discharge, and the discharge disposition. Of great practical importance is the listing of discharge instructions, and the fact that the primary diagnosis uses the H-ICDA classification which obviates the required coding by the medical record clerk.

*Director of Rehabilitation, Burke Rehabilitation Center, White Plains, New York 10605. †Programmer, Cornell University Medical College, New York, New York. ‡Research Assistant, Burke Rehabilitation Center, White Plains, New York 10605.

Work on APG was supported in part by Grant Nos. 50-68 and 67-73 from the National Fund for Medical Education, Grant No. 1008 PE 00480 from HEW, and Grant No. MH25621 from NIMH.

Stroke, Vol. 6, March-April 1975
**FIGURE 1**

**BURKE REHABILITATION HOSPITAL**  
**STROKE REHABILITATION DISCHARGE SUMMARY WORKSHEET**  

<table>
<thead>
<tr>
<th><strong>NAME:</strong></th>
<th><strong>AGE:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TRANSFERRED FROM:**  
(1) NYH, (2) NYC-Hospital, (3) Local Hospital, (4) Other Hospital, (5) Home, (6) Other

**ADMITTED ON:** / /  
**DATE OF DISCHARGE:** / /  
**SEX:** (1) Male, (2) Female

**ETHNIC ORIGIN:** (3) White, (4) Black, (5) PR, (6) Oriental, (7) Other

<table>
<thead>
<tr>
<th><strong>H-ICDA</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>430.1</td>
</tr>
</tbody>
</table>

**PRIMARY DIAGNOSIS:**  
(1) Subarachnoid hemorrhage with paralysis  
(2) Subdural hemorrhage with paralysis  
(3) Other intracranial hemorrhage with paralysis  
(4) Occlusive disease of precerebral arteries with paralysis  
(5) Cerebral thrombosis with paralysis  
(6) Cerebral embolism with paralysis  
(7) Transient ischemic attack with mention of neurological deficit  
(8) Acute, but ill-defined cerebrovascular disease with paralysis

**SEVERITY OF HEMIPLEGIA:** (1) Mild, (2) Moderate, (3) Severe

**TYPE OF HEMIPLEGIA:** (4) Spastic, (5) Flaccid

**MAJOR SITE OF INVOLVEMENT:** (6) Total 1/2 of body, (7) Pred. arm and face, (8) Pred. leg

**ASSOCIATED NEUROLOGICAL CONDITION(S):**  

**ASSOCIATED OTHER CONDITION(S):**  
(1) Arteriosclerotic cardiovascular disease (ASCVD)  
(2) Hypertension  
(3) RHD  
(4) CAD  
(5) Cong. HD  
(6) Renal Disease  
(7) Pulmonary Disease  
(8) GI Disease  
(9) Diabetes  
(10) Dementia  
(11) Seizures  
(12) Fracture(s)  
(13) Depression  
(14) Psychosis  
(15) GU Disease  
(16) Incontinence, bladder  
(17) Incontinence, bowel  
(18) Other

**COMPLICATIONS:**  
(0) None  
(1) Pulmonary embolism  
(2) Pneumonia  
(3) MI  
(4) CHF  
(5) GU infection  
(6) Fracture of hip  
(7) Fracture, other  
(8) Repeat stroke  
(9) Other

**CONDITION ON DISCHARGE:** (1) Improved, (2) Unchanged, (3) Worse, (4) Deceased

**FUNCTIONAL STATUS**

<table>
<thead>
<tr>
<th><strong>LOCOMOTION:</strong></th>
</tr>
</thead>
</table>
| (1) Bedfast  
| (2) Limited to wheelchair  
| (3) Amb. short distances with aids or assistance  
| (4) Amb. with aids (walker, cane[s])  
| (5) Amb. without aids (one cane or less) |

**NEED FOR POST-DISCHARGE DAILY CARE:** (4) Requires no ass't. or supervision

**REQUIRES ASSISTANCE FOR:** (8) Dressing, (9) Personal hygiene, (10) Feeding, (11) Bladder or catheter routine, (12) Bowel routine

**SPEECH:** (13) Normal, (14) Adequate for basic needs, (15) Adequate for employment, (16) Poor

**DISCHARGE DISPOSITION:** (17) Home, (18) Nursing Home, (19) Hospital, (20) SNF, (21) Home Health, (22) OPD, (23) LMD, (24) Other
### Data Base For Stroke Rehabilitation

#### Discharge Medications:

<table>
<thead>
<tr>
<th>Dosage</th>
<th>Schedule</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0) None issued</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### History of Present Illness:

- Onset: 
- (1) Sudden, (2) Evolving, (3) TIE, (4) Head, (5) Other

#### Definitive Neurological Diagnostic Work-Up:

- LP: (0) Not done, Protein—mg%; Color: (1) Bloody, (2) Xanthochr., (3) Clear
- Angiogram: (0) Not done, (1) Normal
- Abnormal: (2) Intracranial obstruct. vasc. disease, (3) Intracerebral hemorrhage, (4) Aneurysm
- EEG: (0) Not done, (1) Localizing, (2) Diff. abnormal, (3) Normal

#### Pertinent Physical, X-ray and Laboratory Findings on Admission to Burke Rehab. Hospital:

<table>
<thead>
<tr>
<th>Physical Symptoms</th>
<th>Le Spasticity</th>
<th>Hema Bilirubin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemiplégia</td>
<td>(1) Right</td>
<td>(17) HHA</td>
</tr>
<tr>
<td></td>
<td>(2) Left</td>
<td></td>
</tr>
<tr>
<td>Hyperreflexia</td>
<td>UE Flaccidity</td>
<td>(18) Ophthalmoplegia</td>
</tr>
<tr>
<td></td>
<td>(3) Right</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4) Left</td>
<td></td>
</tr>
<tr>
<td>Long-Tract Signs</td>
<td>Le Flaccidity</td>
<td>(20) Ataxia and Balance Loss</td>
</tr>
<tr>
<td></td>
<td>(5) Right</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6) Left</td>
<td></td>
</tr>
<tr>
<td>UE Spasticity</td>
<td>Shoulder/Hand Syndrome</td>
<td>(21) Aphasia</td>
</tr>
<tr>
<td></td>
<td>(7) Right</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(8) Left</td>
<td></td>
</tr>
<tr>
<td>Laboratory: Hct</td>
<td>Wbc</td>
<td>Fbs</td>
</tr>
<tr>
<td></td>
<td>Uric Acid</td>
<td>K+</td>
</tr>
<tr>
<td></td>
<td>X-ray Chest:</td>
<td>Other (30 characters)</td>
</tr>
<tr>
<td></td>
<td>(0) Not done</td>
<td>(4) Infarction</td>
</tr>
<tr>
<td></td>
<td>(1) Normal</td>
<td>(5) Empyema</td>
</tr>
<tr>
<td></td>
<td>(2) Acute inflam.</td>
<td>(6) Malignant</td>
</tr>
<tr>
<td></td>
<td>(3) Chronic inflam.</td>
<td>(7) Other (20 characters)</td>
</tr>
<tr>
<td>Skull: (0) Not done</td>
<td>(1) Normal</td>
<td>(4) Craniotomy</td>
</tr>
<tr>
<td></td>
<td>(2) Mass</td>
<td></td>
</tr>
<tr>
<td>Other X-ray: (35 characters)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### EKG:

- (0) Not done, (1) Normal, (2) AF, (3) CAD, (4) BBB, (5) PVC's, (6) MI, (7) LVH, (8) RVH, (9) Other (20 characters)

#### Course in Hospital:

- Rehabilitation: (1) Therapeutic exercises, (2) Walking training, (3) Self-care training, (4) Speech therapy, (5) Other (25 characters)

#### Orthotics:

- (0) None
- (1) Wheelchair
- (2) Cane
- (3) Crutches
- (4) Walker
- (5) Feeding utensils
- (6) Dressing utensils
- (7) Toilet adapt.
- (8) Commode
- (9) Bathroom adapt.
- (10) Hospital bed
- (11) Orthopedic shoes
- (12) Shoe modification
- (13) Foot Ankle Brace
- (14) Ankle Knee Brace
- (15) Knee-cage
- (16) Knee Locking Short Leg Brace
- (17) Long Leg Brace
- (18) Other (25 characters)
Sfrolte, 184

subject to calculation, correlation, or tabulation. He must also
stressed that all discharge summaries contain a description
users who wish to provide their own analytical routines.
providing an additional “on demand” statistical analysis for
these records which can be used for routine statistical
entry is requested, thus preventing storage of inaccurate
Simple validity checks are made by the
required of the attending physician or house
officer to generate a discharge summary is to circle the ap-
appropriate answers to the prepared series of queries which
usually does not take any longer than five to ten minutes.
Options are provided for free text of a predetermined max-
imum character length. A clerical person either from the
respective service or in the record room activates the
program which then, via terminal, presents questions cor-
responding to those on the worksheet and accepts input of
the appropriate data. This again can be accomplished within
five to ten minutes. Simple validity checks are made by the
program on these inputs and only the valid ones are stored.
If an input is invalid, an error message is printed and re-
entry is requested, thus preventing storage of inaccurate
data. Each query is presented in turn until the data entry is
completed. On the appropriate output command the APG
program will produce a typewritten English text discharge
summary on any kind of stationery (up to six carbon copies)
for signature, two to three minutes after completion of input
and, of course, any time thereafter. Again, the fact is
stressed that all discharge summaries contain a description
of the patient’s functional status at discharge and a complete
record of his current medications (fig. 2).

PROGRAMMING
This phase had previously been the domain of professional
programmers well versed in APL application. Although it is
now possible for medical personnel to write their own
programs, we decided to retain a programmer and employ
the necessary consultations. For example, it is helpful to the
programmer to know in advance which data might be sub-
ject to calculation, correlation, or tabulation. He must also
be provided with upper and lower bounds for questions such
as laboratory findings for the inclusion of validity checks
into the final program. As stated before, the programmer
must also be provided with a sample text of a discharge sum-
mary which will enable him to program the basic prose to
which these variables are either added or inserted.

OPERATION
All that is required of the attending physician or house
officer is to respond to those on the worksheet and accept input of
the respective data. This again can be accomplished within
five to ten minutes. Simple validity checks are made by the
program on these inputs and only the valid ones are stored.
If an input is invalid, an error message is printed and re-
entry is requested, thus preventing storage of inaccurate

Results
Figure 2 shows a sample of the English text output in the
form of a discharge summary. Figure 3 shows a
routine statistical report covering a period from
January 1, 1974 through September 30, 1974. The
program allows for report generation over variable
time spans by just specifying starting and ending
dates. This way reports can be printed out daily,
monthly, quarterly, or annually.

The report (fig. 3) illustrates that 138 patients
with stroke of all specified causes were discharged from the Stroke Unit. As expected, cerebral throm-

Discussion
EFFECTS ON PATIENT CARE
The capability of producing a computerized English
prose discharge summary is not only time saving and
convenient for the physician, but is directly beneficial
to the quality of patient care. Provided with a dis-
charge summary on the day of discharge, patients can
carry information about their hospitalization to their
personal physicians and copies can be mailed to the
visiting nurse associations or the other agencies or in-
dividuals involved in their welfare. The interactive
questionnaire-type program also reminds the attend-

utilization of data base
The presented statistical report is but one fairly

BRACING MATERIAL: (1) Plastic, (2) Metal, (3) Composite
MEDICAL: (0) None (1) Antihypertensive (2) Cardiac (3) Anticoagulation
(4) Diuretic (5) Antihyperglycemic (6) Psychotropic (7) Antibiotics
COMPLICATIONS: (8) CHF (9) Arrhythmia (10) AF (11) Arthritis
(12) Hip fracture (13) Repeat stroke (14) Seizure (15) Other (45 characters)

PROGRAMMING
This phase had previously been the domain of professional
programmers well versed in APL application. Although it is
now possible for medical personnel to write their own
programs, we decided to retain a programmer and employ
the necessary consultations. For example, it is helpful to the
programmer to know in advance which data might be sub-
ject to calculation, correlation, or tabulation. He must also
be provided with upper and lower bounds for questions such
as laboratory findings for the inclusion of validity checks
into the final program. As stated before, the programmer
must also be provided with a sample text of a discharge sum-
mary which will enable him to program the basic prose to
which these variables are either added or inserted.

OPERATION
All that is required of the attending physician or house
officer is to respond to those on the worksheet and accept input of
the respective data. This again can be accomplished within
five to ten minutes. Simple validity checks are made by the
program on these inputs and only the valid ones are stored.
If an input is invalid, an error message is printed and re-
entry is requested, thus preventing storage of inaccurate

Results
Figure 2 shows a sample of the English text output in the
form of a discharge summary. Figure 3 shows a
routine statistical report covering a period from
January 1, 1974 through September 30, 1974. The
program allows for report generation over variable
time spans by just specifying starting and ending
dates. This way reports can be printed out daily,
monthly, quarterly, or annually.

The report (fig. 3) illustrates that 138 patients
with stroke of all specified causes were discharged from the Stroke Unit. As expected, cerebral throm-

Discussion
EFFECTS ON PATIENT CARE
The capability of producing a computerized English
prose discharge summary is not only time saving and
convenient for the physician, but is directly beneficial
to the quality of patient care. Provided with a dis-
charge summary on the day of discharge, patients can
carry information about their hospitalization to their
personal physicians and copies can be mailed to the
visiting nurse associations or the other agencies or in-
dividuals involved in their welfare. The interactive
questionnaire-type program also reminds the attend-

utilization of data base
The presented statistical report is but one fairly
prosaic example of data analysis. There are much more data available for statistical routines than the report shows. Programs for its analysis can be constructed to meet changing requirements. The special "on demand" statistical analysis is nearing completion and the results will be reported at a later date.

COMPUTER STORAGE CAPACITY
Our data are stored on magnetic disks in what is called an APL dataspace (DS). A standard DS consists of approximately 600,000 bytes of information. We have chosen for the stroke discharge program to use about one-third of this capacity, allowing us a maximum of 400 records. When a given program has filled its assigned storage, its data can be archived on magnetic tape, allowing reuseage of the DS. Thus stored, data can be reloaded into the computer at any time for display and analysis.

CONFIDENTIALITY
The lay and professional public is concerned with the confidentiality of computerized medical records. In the described program, records are entered by both name and hospital (unit number), but names can be omitted and kept separately from the corresponding hospital numbers in the medical records room. A series of "pass words" are necessary to gain access to the computer system, and access to these can be easily limited.

OTHER APPLICATIONS
At the Burke Rehabilitation Center a program for computerized discharge summaries for amputee
FIGURE 3

BURKE REHABILITATION HOSPITAL
DISCHARGES DURING THE PERIOD 01/01/74 THROUGH 09/30/74

PATIENTS DISCHARGED (all diagnoses) ................................................. 138
   Male ................................................................. .64
   Female ........................................................... .74

DIAGNOSES:
   Subarachnoid Hemorrhage with Paralysis (H-ICDA 430.1) .................. .4
   Subdural Hemorrhage with Paralysis (H-ICDA 431.1) ........................ 0
   Intracranial Hemorrhage with Paralysis (H-ICDA 431.3) .................... 3
   Occlusive Disease of Precerebral Arteries with Paralysis (H-ICDA 432.1) 5
   Cerebral Thrombosis with Paralysis (H-ICDA 433.1) ........................ 58
   Cerebral Embolism with Paralysis (H-ICDA 434.1) .......................... 35
   Transient Ischemic Attack with Mention of Neurological Deficit (H-ICDA 435.1) 6
   Acute but Ill-Defined Cerebrovascular Disease with Paralysis (H-ICDA 436.1) 27

HEMIPLEGIA, Right .................................................... .71
   Left ............................................................. .66
   Unspecified ..................................................... 1

SEVERITY, Mild ................................................. .30
   Moderate ....................................................... .60
   Severe ......................................................... .47
   Unspecified ................................................... 1

DISCHARGE DISPOSITION (Note: some patients may be enumerated in more than one category)
   Home ........................................................... 103
   Nursing Home ................................................. .14
   Hospital ......................................................... 4
   SNF ............................................................. 0
   Home Health ................................................... 3
   OPD ............................................................. 7
   LMD ............................................................. 12
   Other ........................................................... 20

AGE (138 patients): YEARS
   Minimum ....................................................... .30
   Maximum ....................................................... .85
   Mode ........................................................... .58
   Mean ............................................................ .67
   Median .......................................................... .70

LENGTH OF STAY (138 patients):
   Minimum ....................................................... .7
   Maximum ....................................................... 121
   Mode ........................................................... .64
   Mean ............................................................ .45
   Median .......................................................... .42

ONSET-ADMISSION INTERVAL (138 patients):
   Minimum ....................................................... .11
   Maximum ....................................................... 176
   Mode ........................................................... .94
   Mean ............................................................ .39
   Median .......................................................... .34

rehabilitation and subsequent establishment of a data base for this category of patients was recently completed. Other programs concerned with hip fractures, cardiac rehabilitation, and spinal cord injuries are either in preparation or planned. The APG program is also used, nota bene, for hospital and medical school, administrative, fiscal and teaching programs. The described system is ideally suited for multicenter, cooperative clinical evaluations concerned with diagnosis or treatment of stroke, since it provides the means for uniform data collection and analysis.

Summary
A terminal-oriented, interactive computer system is described, programmed in APL. The objective was to computerize English text discharge summaries for improving the quality of care for patients treated at a stroke rehabilitation unit. The establishment of a data
DATA BASE FOR STROKE REHABILITATION

base, using the stored data, allows analysis of a variety of factors concerned with stroke rehabilitation in a most elegant and time-saving manner.

References
1. Stern PH, Miller J: Quantitative evaluation of long-term L-Dopa treated patients with parkinsonism using a computer terminal. Presented at the Sixth International Congress of Physical Medicine, Barcelona, Spain, 1972
Data Base for Stroke Rehabilitation Using Computerized English Text Discharge

Summaries

PETER H. STERN, JAY C. LINCOLN and MARILYN B. ROBINSON

*Stroke*. 1975;6:181-187
doi: 10.1161/01.STR.6.2.181

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1975 American Heart Association, Inc. All rights reserved.
Print ISSN: 0039-2499. Online ISSN: 1524-4628

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/6/2/181

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to *Stroke* is online at:
http://stroke.ahajournals.org/subscriptions/