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.²³

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.
STERN, LINCOLN, ROBINSON

FIGURE 1
BURKE REHABILITATION HOSPITAL
STROKE REHABILITATION DISCHARGE SUMMARY WORKSHEET

NAME: 
H.N.: 
M.D.: 
AGE: 

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

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

H-ICDA
430.1
431.1
431.3
432.1
433.1
434.1
435.1
436.1

SEVERITY OF HEMIPLEGIA: (1) Mild, (2) Moderate, (3) Severe
TYPE OF HEMIPLEGIA: (4) Spastic, (5) Flaccid

MAJOR SITE OF INVOLVEMENT: (6) Total ½ of body, (7) Pred. arm and face, (8) Pred. leg
ASSOCIATED NEOUROLOGICAL CONDITION(S): (1) Dysphasia, receptive, (2) Dysphasia, expressive,
(3) Global, (4) Dysarthria, (5) Ophthalmoplegia, (6) HHA, (7) Dysphagia, (8) Ataxia and
balance loss, (9) Other (25 characters)

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

(50 characters)

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
(25 characters)

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

FUNCTIONAL STATUS

LOCOMOTION:
(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: (6) 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 (20 characters)
### DISCHARGE MEDICATIONS:

<table>
<thead>
<tr>
<th>MEDICATION</th>
<th>DOSAGE</th>
<th>SCHEDULE</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0) None issued</td>
<td></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) Xanthochromic
    - (3) Clear

- **ANGIOGRAM:**
  - (0) Not done
  - (1) Normal
  - Abnormal:
    - (2) Intracranial obstructive vascular disease
    - (3) Extracranial obstructive vascular disease
    - (4) Aneurysm

- **EEG:**
  - (0) Not done
  - (1) Localizing
  - (2) Diffuse abnormal
  - (3) Normal

### PERTINENT PHYSICAL, X-RAY AND LABORATORY FINDINGS ON ADMISSION TO BURKE REHAB. HOSPITAL:

#### PHYSICAL SYMPTOMS:

- **HEMIPLEGIA**
  - LE SPASTICITY:
    - (1) Right
    - (2) Left
  - UE SPASTICITY:
    - (3) Right
    - (4) Left

- **HYPERREFLEXIA**
  - LE FLACCIDITY:
    - (5) Right
    - (6) Left
  - UE FLACCIDITY:
    - (7) Right
    - (8) Left

- **LONG-TRACT SIGNS**
  - LE FLACCIDITY:
    - (9) Right
  - UE FLACCIDITY:
    - (10) Right

- **UPPER EXTREMITY SPASTICITY**
  - SHOULDER/HAND SYNDROME:
    - (11) Right
    - (12) Left

- **LABORATORY:**
  - HCT
  - Uric Acid
  - K+
  - WBC
  - FBS
  - BUN
  - Creatinine

- **X-RAY CHEST:**
  - (0) Not done
  - (1) Normal
  - (2) Acute inflammation
  - (3) Chronic inflammation

- **SKULL:**
  - (0) Not done
  - (1) Normal
  - (2) Mass

### EKG:

- (0) Not done
- (1) Normal
- (2) AF
- (3) CAD
- (4) BBB
- (5) PVCs
- (6) MI
- (7) LVH
- (8) RVH
- (9) Other

### COURSE IN HOSPITAL:

- **REHABILITATION:**
  - (1) Therapeutic exercises
  - (2) Walking training
  - (3) Self-care training
  - (4) Speech therapy
  - (5) Other

- **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
Sfrolte, 184

ject 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 reports. However, the APG program has the capability of these records which can be used for routine statistical a record in the computer. A file consists of a collection of

The data contained in the summary worksheet are stored as

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

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 subject 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 summary 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 to generate a discharge summary is to circle the 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 maximum character length. A clerical person either from the respective service or in the record room activates the program which then, via terminal, presents questions corresponding 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).

ANALYSIS
The data contained in the summary worksheet are stored as a record in the computer. A file consists of a collection of these records which can be used for routine statistical reports. However, the APG program has the capability of providing an additional "on demand" statistical analysis for users who wish to provide their own analytical routines.

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:
(0) None
(1) Pulm. infarct.
(2) Pneumonia
(3) URI
(4) GU infection
(5) BPH
(6) Urinary retention
(7) MI
(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 subject 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 summary 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 to generate a discharge summary is to circle the 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 maximum character length. A clerical person either from the respective service or in the record room activates the program which then, via terminal, presents questions corresponding 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).

ANALYSIS
The data contained in the summary worksheet are stored as a record in the computer. A file consists of a collection of these records which can be used for routine statistical reports. However, the APG program has the capability of providing an additional "on demand" statistical analysis for users who wish to provide their own analytical routines.

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 thrombosis (H-ICDA 433.1) was the leading cause. Based on functional losses, most of the patients had either moderate or severe hemiplegia. One hundred and eight (78%) of this group were able to return home rather than being placed in an institutional environment. The mean age was 68 and the average length of stay was 44 days. The time interval between onset of stroke and admission to the Stroke Rehabilitation Unit averaged 40 days. The ranges of values are also listed, and the program can identify these records for special scrutiny.

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 discharge 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 individuals involved in their welfare. The interactive questionnaire-type program also reminds the attending physician and allied health personnel of possible omissions in patient care.

UTILIZATION OF DATA BASE
The presented statistical report is but one fairly
### Data Base for Stroke Rehabilitation

#### Figure 2

**The Burke Rehabilitation Hospital**

<table>
<thead>
<tr>
<th>Summary</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admitted: 05/02/74</td>
<td>Discharged: 08/29/74</td>
</tr>
<tr>
<td>Length of Stay: 120 days</td>
<td>Onset-Admission Interval: 26 days</td>
</tr>
</tbody>
</table>

**Primary Diagnosis:** cerebral thrombosis with paralysis H-ICDA 433.1.

**Associated Conditions:** ASCVD, hypertension, diabetes, and bladder incontinence.

**Complications:** GU infection.

**Condition on Discharge:** improved.

**Functional Status:**
- Locomotion: ambulates with aids.
- Post-discharge Care: assistance required for dressing, and personal hygiene.
- Speech: poor.

**Discharge Note:**
1. Reason for Entering Hospital: This 52-year-old white male was admitted for stroke rehabilitation because of a severe flaccid hemiplegia with receptive \( \text{d}_{1} \)-aphasia, expressive dysphasia, and \( \text{R} \) central facial paralysis as a result of a cerebral thrombosis. Associated with this was ASCVD, hypertension, diabetes, and bladder incontinence.

2. Pertinent Past History: Stroke onset was evolving on 04/06/74. The patient was transferred here from a NYC hospital. Complications included lq. pressure sore \( \text{R} \) ankle.

3. Pertinent Physical, X-ray, and Lab Findings on Admission: BP was 156/86; PR was 72; Temp. was 37.0 C. Physical symptoms included \( \text{R} \) hemiplegia, \( \text{R} \) hyperreflexia, \( \text{R} \) long-tract signs, \( \text{R} \) UE flaccidity, dysphasia, and hemisensory loss. HCT was 41.5; WBC 7,500; FBS 168 mg\%. Other lab findings included: chol: 210, triglycerides:110. Chest X-ray: normal. Other X-rays showed IVP: within normal limits. EKG: normal.

4. Course in Hospital: This patient was on a program of rehabilitation consisting of therapeutic exercises, walking training, self-care training, speech therapy, and Rx pressure sore. He was treated with antihypertensive, antihyperglycemic, and antibiotic medication. He experienced GU infection as a complication. He was supplied with metal foot-ankle brace.

**Discharge Disposition:** home.

**Discharge Medications:**
1. Aldomet 500 mg qid
2. Diabinase 500 mg qd
3. Hyprex 1,000 mg bid
4. Ascorbic acid 500 mg bid
5. Diet: 1,000 cal diabetic, reducing

Signed: ______________________________ M.D.

---

A 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 reusage 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): DAYS
   Minimum .................................................... 7
   Maximum ................................................... 121
   Mode ......................................................... 64
   Mean ......................................................... 45
   Median ....................................................... 42

ONSET-ADMISSION INTERVAL (138 patients): DAYS
   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 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.
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/