DESIGNING A COMPUTER-ASSISTED CLINIC
TO COPE WITH THE EVOLUTION OF PACEMAKER TECHNOLOGY

Catherine N. Pfeil, Paul D. Keltz, Edward W. Gertz, Melanie H. Okawachi

Cardiac Catheterization Laboratory (111C1)
Veterans Administration Medical Center
4150 Clement Street, San Francisco, CA 94121

Abstract

A computer-assisted program for follow-up monitoring of implanted cardiac pacemakers has been in operation at the San Francisco Veterans Administration Medical Center since 1977. It was originally created at a time when the technology of pacemakers was stable and only a few parameters could be measured or telemetered. Two recent developments have necessitated a major reassessment of this project as well as redesign of the entire computer infrastructure: the advent of multi-programmable and multi-chamber pacemakers (presenting a wide variety of selectable and interacting parameters and features) and the expansion of the program to follow 4000 patients. In addressing the above two problems we have embarked on a project which involves distributed data structures, interactive multitasking and non-deterministic data structures. The resultant computer-based system will allow for maximum flexibility in the definition of data for differing pacemakers while permitting coherent and meaningful studies to be performed across large patient populations.

Introduction

In 1977 the San Francisco VA Medical Center initiated a computer-assisted pacemaker surveillance program. The primary objectives of this program were to collect data reflective of the individual patient's pacemaker performance (via telephone contact), to generate a cumulative and concise report illustrating the pacemaker performance and characteristics, to ensure that patients were not lost to follow-up, to review each pacemaker model's performance across many patients and to use that aggregate data to positively affect the individual patient's care.

Operationally, the system was to be highly responsive, providing rapid access to all relevant patient parameters at the time of telephone contact. As each contact was to be relatively short in duration, the access had to be efficient with minimal user interaction.

Current Status of the System

To date, all the objectives listed above have been realized for a population of over 1300 patients, 17 pacemaker manufacturers, more than 200 pacemaker models and sixteen VA medical centers. When the project was initiated, a finite and well understood set of pacemaker and patient parameters were determined to

be key in the analysis of pacemaker definition and function. Special emphasis was placed on the magnet rate as this measurement was usually a measure of the pacemaker's function. Thus, for each patient contact, updates to this fixed data set were collected and a cumulative report was generated (see Figure 1)

As the completion of each patient contact, an appointment for the next contact is made. As an added insurance measure of reliability against losing patients to follow-up, the system routinely verifies all active patients to be on the contact schedule.

As a special and unique feature, the system searches the database for all instances of user specified pacemakers. The output of this search produces lists of patients and their respective pacemaker history. This data is also channeled to a graphics package to yield an aggregate picture of the observed performance of the pacemaker model as a function of magnet rate and device age. These graphic displays show trends in long-term performance which can then suggest to the clinical staff to the possibility of adjusting patient contact schedules. In extreme cases, the clinic can also easily contact patients with the reviewed model for scheduling immediate replacement of the unit.

All these data collection and output generation components are based on a traditional computer system using conventional and fully deterministic data management techniques. Therefore, each pacemaker record is logically identical although the physical size varies according to the number of contacts producing evaluative data for cumulative reports.

Stimulation for Change

Despite its success, the computer-based support for the pacemaker surveillance clinic must be completely restructured. This redesign is not intended to redefine the basic goals as they remain the crux for successful operation. Rather, they are external influences which weaken the initial system's utility and functionality.

The first and foremost of the external influences is the advent of multi-chamber and multi-programmable pacemakers. These new pacemaker models are proliferating at an astounding rate with no standardization or expectations of standardization

Furthermore, it is fully expected that the current trend is only a precursor of the diversity and imaginative function of pacemakers to come. At present, each

**NAME:** SAMPLE, TEST  
**DATE OF BIRTH:** DD MMM YY  
**PHONE:** XXX-XXX-XXXX  
**REF PHYS:** J. SMITH, M.D.  
**GENERATOR MFG:** BRAND X  
**SERIAL #:** XXXXXX  
**BOL RATE:** 75.2  
**BOL MAGNET RATE:** 75.2  
**BOL PULSE WIDTH:** .52  
**GENERATOR AGE:** 4 YRS, 5 MOS  

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**ACCESSION #:** XXXX  
**PATIENT #:** XXX-XX-XXXX  
**SEX:** M  
**REF HOSP:** ANOTHER VAMC  
**MODEL:** XXXXXX  
**ICHD TYPE:**  
**EOL RATE:** 67.8  
**EOL MAGNET RATE:** 67.8  
**EOL PULSE WIDTH:** .586  
**INDICATION:** CHB  

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**PLOT OF MAGNET RATE VS TIME**

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**TEST DATE** | **RATE** | **INTERVAL** | **CAPTURE** | **SENSE** | **P WIDTH** | **MAGNET**  
| | (MSEC) | | | |  
| 18 FEB 82 | INSR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MAGNET |  
| 1 | 75.1 | 798 | Y | | | |  
| 18 MAR 82 | INSR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MAGNET |  
| 1 | 75.0 | 800 | Y | | | |  
| 15 APR 82 | INSR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MAGNET |  
| 1 | 75.1 | 798 | Y | | | |  
| 13 MAY 82 | INSR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MAGNET |  
| 1 | 75.0 | 800 | Y | | | |  
| 10 JUN 82 | INSR | 1 | 1 | 1 | 1 | 1 | 1 | 1 | MAGNET |  
| 1 | 74.9 | 801 | Y | | | |  

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**SOME SINUS RHYTHM THEN SLOWS TO PACE, NORMAL CHECK, NEXT CALL - JULY 8**

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**FIGURE 1: Pacemaker Patient Report**
The second external influence is a result of the success and subsequent expansion of the pacemaker surveillance program which continues to meet basic functional goals, a major cyclical and non-deterministic data. Whereas some data will continue to be uniform or predictable (e.g., patient address, next of kin), the specification of a pacemaker model may be non-deterministic. Beyond this, the evaluation of the pacemaker performance at the time of patient contact will be dependent on the specification of the generator as it was last programmed. To accommodate this unpredictable data, the new system will be supported by "Smart Files" which will allow for dynamic, user-defined data maps. As each patient is registered, the current status of his pacemaker can be defined from a map. Subsequent reprogramming of the pacemaker will then "deactivate" the individual patient's current definition of the pacemaker model and introduce a new one which defines the same pacemaker in an altered mode of operation. It is important to note that the definition of the individual's pacemaker may be as non-deterministic as the map for the full capabilities of the pacemaker model. Thus, each contact may yield a distinct set of parameters. Each of these parameters may impact the clinical evaluation of the pacemaker's performance and hence the extra effort involved in capturing these data is a critical step in upgrading the system.

Use of modular tasks with intertask communication will increase the maintainability, flexibility and responsiveness of the system. This approach is also useful in providing an efficient means for adding functionality to the system.

Experimentation with the "smart files" and interdependent modular tasks has been underway for several months. Initial efforts have resulted in a responsive, flexible system. Work is still underway on this project. Specifically, the non-deterministic quality of the pacemaker data will necessitate further refinement and experimentation with the technique. However, the approach has shown to be promising and it is intended to continue and complete the system according to the projected plan.

Conclusions

The computer-assisted pacemaker surveillance program at the San Francisco VA Medical Center has experienced two major external impacts: the advent of new technology in pacemaker design and a significant increase in patient population. Whereas the initial system continues to meet basic functional goals, a major overhaul is essential to compensate for the changing environment. The resulting computer-assisted system will support a multi-tasked set of interactive modules managing both deterministic and non-deterministic data. The expected outcome will yield a data management system which continues to meet clinical goals while promoting coherent and flexible management of patient and pacemaker data.

References