Biomedical Engineering: Opening New Doors

Edited by

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FOREWORD

This New York University Series entitled Monographs in Biomedical Engineering is intended to complement the very popular New York University textbook series in Biomedical Engineering. The Monographs series is dedicated to making available in a timely manner full Proceedings of Conferences, Meetings (such as the Annual Fall Meeting of the Biomedical Engineering Society), Workshops, Seminars, and other Specialty Symposia that have as their theme topics in the fast-growing field of Biomedical Engineering.

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DANIEL J. SCHNECK
Virginia Tech

PREFACE

Biomedical Engineering: Opening New Doors is a report of the proceedings of the 1990 Fall Annual Meeting of the Biomedical Engineering Society. This volume contains five sections, each devoted to a special area of biomedical engineering. The spectrum spanned by these presentations indeed is an opening of many new doors into the research of the next century. Some of these new areas have already become easily recognized as topics for the popular press, while others remain less conspicuous as their students push forward without as much fanfare. Nonetheless, each in its own way stakes out territory for future exploration and new sources of excitement.

New methods of mathematical modeling, imaging and computation encompass neural networks and other forms of artificial intelligence. Networks also appear as network thermodynamics is utilized. Artificial intelligence is applied to life support and other applications. Many techniques for looking at organs and tissue designed to perturb these structures as little as possible are explored. The new uses of biotechnology are also discussed.

All together these diverse topics have a common theme, namely the opening of doors to the future of biomedical engineering. We sincerely hope the reader will find them as exciting as we have while preparing this volume. We want to give special thanks to the session organizers, Dr. Alex M. Clarke (Physiological measurements and life support technologies), Dr. John Tyson (Mathematical Models in Molecular Biology and Physiology), Dr. Arthur Johnson (Biotechnology), Dr. Michael Merickel (Non-invasive detection of tissue and organ failure: Imaging), and Dr. Gene A. Tagliarani (Engineering aspects of cognitive sciences) We also wish to thank the Whittaker Foundation for their generous support. A special thanks goes to Jack Lilly, Program Development Specialist, and his staff at the Donaldson Brown Center for Continuing Education, for their gracious hosting of this conference, and to

Jason Renker and all of his colleagues at the N.Y.U. Press for their encouragement and timely publication of the Proceedings volumes. We are proud to be part of this great team and are grateful to so many dedicated people for helping make this conference a success.

Donald C. Mikulecky
Editor

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Editor and Session Organizer and Chair, Physiological Measurements and Life Support

October, 1990
Virginia Commonwealth University,
Richmond, Virginia

I.

PHYSIOLOGICAL MEASUREMENTS AND LIFE-SUPPORT TECHNOLOGIES

TABLE OF CONTENTS

A PROMPTING AND DATA COLLECTION SYSTEM FOR USE IN MEDICAL DEPARTMENTS DURING CPR

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ABSTRACT

The development of systems for accurate recording of both the medical protocols and treatment undertaken, together with the resulting electrocardiographic, blood pressure, and other physiologic responses, all carefully "time-stamped," was undertaken to help optimize cardiopulmonary resuscitation, and provide the detailed records necessary for continued treatment while the patient is in the hospital. These systems also allow scrutiny of the procedure for accuracy, billing, and even, should a Regional or National Consortium be instituted, rapid determination whether changes in the recommendations of the ACLS and other groups result in increased survival rates. In this paper, the parameters of the systems will be described. The potential of the system lies in the adoption of a national standard for the reporting of this data, such that future changes in treatment protocols to improve CPR can be taken to trial more efficiently

INTRODUCTION

In the pressured, highly charged atmosphere surrounding a cardiac resuscitation attempt in the emergency department, meticulous documentation of all treatment is essential for a hospital to provide optimal health care. Two microcomputer-based data management and acquisition systems have been developed. The systems have as a central requirement that they be user-friendly and interactive, and that they be easily and intuitively used by physicians and nurses during a cardiac emergency. The system is a more accurate, efficient, and

reliable method of data management than the hand-written records currently compiled at most hospitals.

The modern microcomputer has numerous intrinsic characteristics lending itself to an excellent emergency care data management system. The speed of the computer allows quick and simple entry of important events in much greater detail than hand-written efforts. These inputs may be easily time-stamped and stored in a chronological manner by the computer for real-time and subsequent review. The electrocardiogram and other analog waveforms monitored during the cardiac emergency can easily be sampled by the computer and stored for later reconstruction and analysis.

While microcomputer-based documentation systems for the intensive care unit of the hospital are of great value in their setting, cardiac emergencies present quite different obstacles to be overcome by a data management system. An ICU system is usually designed to accept relatively infrequent entry of information concerning numerous patients over a relatively long period of time (days to weeks). In contrast, a cardiac resuscitation data management system is required to frequently collect in-depth information concerning one patient over a short period of time (minutes to hours). During the cardiac resuscitation, the system's emphasis must be speed, ease of entry, and ease of review. These considerations are important, but not critical, in the hospital ICU setting.

The set of entries to be logged by a data management system during a cardiac resuscitation is unique, including selections such as defibrillation, detection of various arrythmias, and administration of drugs commonly used during CPR. An important need of the cardiac resuscitation data management system is a combination of in-depth logging of treatment events and digital storage of monitored patient signals. Most ICU systems which allow detailed entry of clinical events do not include a data acquisition module and are not designed for fast-paced entry.

THE SYSTEMS

Two systems have been developed at the Medical College of Virginia in conjunction with the Hospitals Emergency Department. The first is written in "C", requires a 80286 or 80386 based microcomputer compatible with the Microsoft disk

operating system, 512 kilobytes of RAM, and a 20 megabyte or larger hardfile that has an access time of 30 ms or better. The data acquisition board used for this particular system is the Labmaster DMA <tm> produced by Scientific Solutions, with 12 bits of analog to digital resolution, and 40 kHz sampling capability. The program is written in modules, simplifying changes in both the the hardware and software configurations, as well as facilitating changes in the treatment protocols.

The second system is written in Borland Turbo Prolog, chosen for its increased in graphic capability and the potential for the development of an Artificial Intelligence shell. Several modules have been written in Assembly Language, where Prolog was too slow. Use of Extended Memory as well as 80386 and 80387 specific code limits this system to a 80386/80387 based machine, preferably with 2 megabytes of RAM or more. The data acquisition board is the Metrabyte Dash 16 <tm>. Interface to the patient is made through the patient monitor which has is the standard at the MCV Hospitals, the Mennen Horizon 2000.

Upon activation of the system, a menu, a protocol flow sheet, and pull-down window appears, with the most prevalent condition observed at the admission of a patient to the resuscitation unit of the Emergency Department displayed. Movement through the cascaded menus is possible with either a "Mouse," or the cursor keys. Movement has been designed to be as intuitive as possible, with conditions and responses most often encountered being in the default position in the individual menu. Data collection to the flowsheet commences with activation of the system. However, the analog signal acquisition is activated only on command, as the connection to the patient is sometimes delayed during the first few moments of the CPR attempt. As many as 5 analog signals may be displayed in a window occupying the bottom third of the screen. For the Mennen monitor, the digital signal containing the mean, diastolic, and systolic blood pressures, heart and respiration is read, displayed, and automatically entered when vital signs are requested.

Included in the documentation are drug administrations, heart rhythm observation, vital signs, intubations, and numerous other cardiac resuscitation procedures. Upon selection of a particular item, the data management system leads the user through a series of cascading menus prompting entry of the most pertinent treatment information. The change of menus, cursor movement, and display update appear instanta-