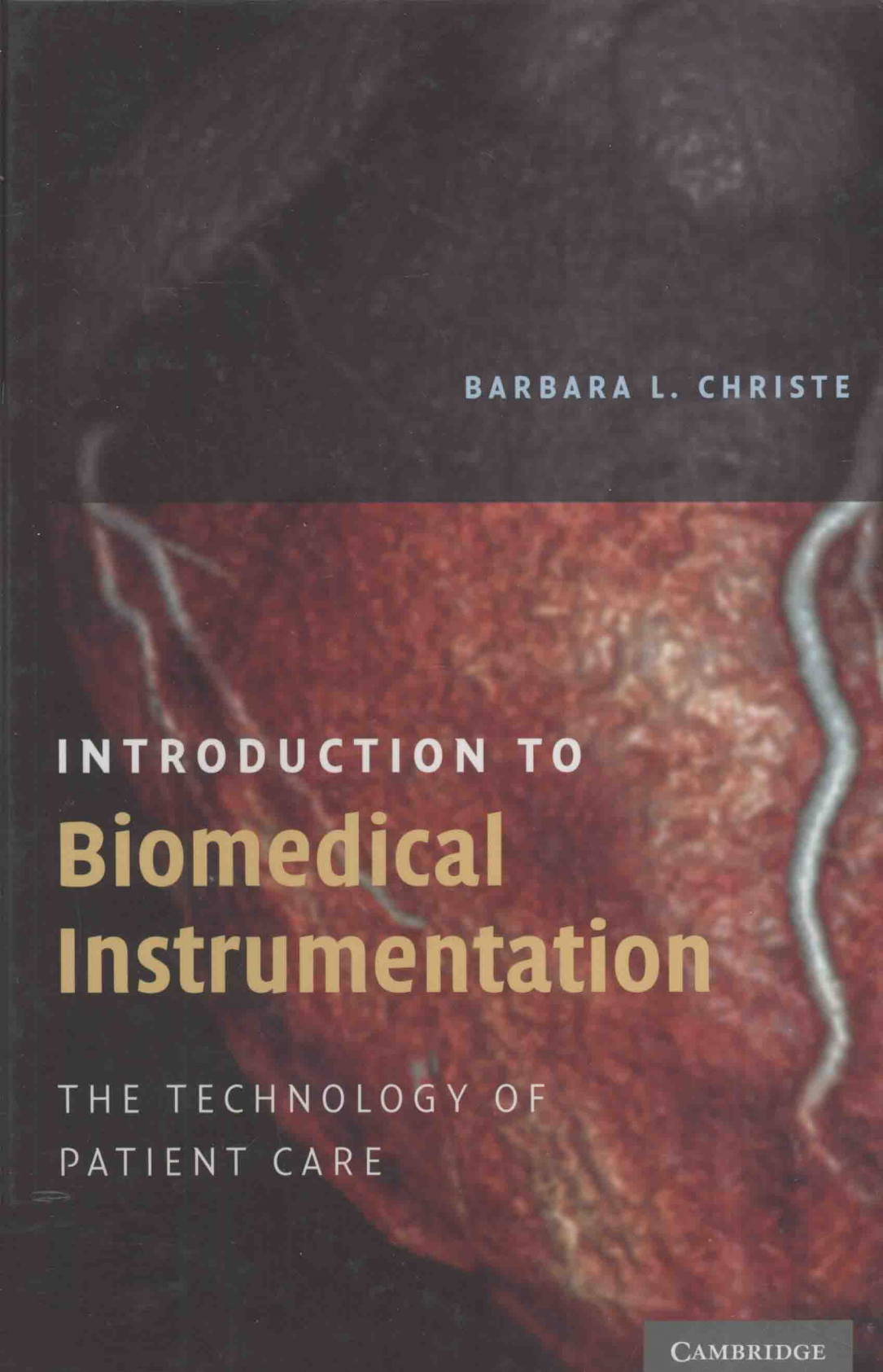
BARBARA L. CHRISTE
INTRODUCTION TO
Biomedical
Instrumentation
THE TECHNOLOGY OF
PATIENT CARE
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INTRODUCTION TO BIOMEDICAL INSTRUMENTATION

The Technology of Patient Care

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INTRODUCTION TO BIOMEDICAL INSTRUMENTATION

The Technology of Patient Care

This book is designed to introduce the reader to the fundamental information necessary for work in the clinical setting, supporting the technology used in patient care. Beginning biomedical equipment technologists can use this book to obtain a working vocabulary and elementary knowledge of the industry. Content is presented through the inclusion of a wide variety of medical instrumentation, with an emphasis on generic devices and classifications; individual manufacturers are explained only when the market is dominated by a particular unit. This book is designed for the reader with a fundamental understanding of anatomy, physiology, and medical terminology appropriate for their role in the health care field and assumes the reader's understanding of electronic concepts, including voltage, current, resistance, impedance, analog and digital signals, and sensors. The material covered in this book will assist the reader in the development of his or her role as a knowledgeable and effective member of the patient care team.

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Preface

This book serves readers who would like to explore medical equipment that is used in the clinical setting. It offers an overview of the fundamental information necessary for work in the field. The material is designed to provide a working vocabulary and *elementary* knowledge of the medical equipment involved in the treatment of patients. Readers are encouraged to become knowledgeable and effective members of the patient care team, building on the information in this book as a foundation for further study.

Readers should have a fundamental understanding of *anatomy, physiology, and medical terminology* appropriate for their role in the health care field. Readers are assumed to have a fundamental knowledge of *basic electronics* concepts including voltage, current, resistance, impedance, analog and digital signals, and sensors. Readers without this background may have to explore terms and concepts referenced in the text.

There is a vital connection between technology and the care of patients. In many cases, health care workers depend on technology to administer care or treatment or to make a diagnosis. This book helps readers understand how technology is tightly woven into patient care. The role of technical support for the medical team is, therefore, essential in the delivery of effective medical care.

The section of each chapter entitled "For Further Exploration" encourages readers to use the Internet to obtain in-depth information about a topic. Questions are designed to push the reader to integrate concepts using external sources. Answers are not specifically available within the chapters. While Wikipedia (http://www.wikipedia.com) may not be an academically authoritative source, it is often an excellent starting point for research. Research exercises encourage one of the most important skills of a successful biomedical equipment technician (BMET) – investigation of topics that are not well understood. In the clinical setting, it is impossible to be an expert about all technology and aspects of patient care. The ability to effectively search for information is vital.

All photographs (unless otherwise noted) are by Valerie Shiver.

Special appreciation is extended to my collegiate mentors, Dean Jeutter and Joe Bronzino. I am in debt to my colleagues in higher education, Steve Yelton, Roger Bowles, Elaine Cooney, and Ken Reid, as well as those who have supported me in the clinical setting, including Dave Francouer, Karen Waninger, Kelly Vandewalker, Steve Erdosy, and Bob Pennington. Without their encouragement, this book could not have been written. Lastly, to my parents and children, I am deeply grateful for their love and understanding.

Those who support the technology used in patient care are a dedicated and selfless part of the workforce. They are part of the medical team and have excellent technical skills. Most importantly, BMETs work closely with staff to ensure safe and effective patient care. May this book be the beginning of a transformation that increases career awareness, improves enrollment in training programs, and expands the recognition BMETs deserve.

INTRODUCTION TO BIOMEDICAL INSTRUMENTATION

The Technology of Patient Care

Contents

1

BMET as a career

LEARNING OBJECTIVES

1. describe the role of a BMET
2. list and describe potential employers of a BMET
3. characterize field service representatives
4. list and describe the many job functions of a BMET
5. list and characterize the certification requirements
6. list and describe related professional societies and journals

What is the name of this career?

There are many definitions for what the letters BMET stand for – biomedical equipment technician, biomedical electronics technology, medical maintenance, biomedical engineering technologist, biomedical engineer, medical engineer, medical equipment repair technician, and many more. In general, it is the title for someone who works in the clinical setting and supports the equipment involved in patient care.

At different hospitals, staff may have a wide variety of titles. Staff may be called the "biomeds," "clinical engineers," or the "equipment guys." In some hospitals, BMETs may be responsible for everything from printers to computers to DVD players in the rooms of patients. In some hospitals, BMETs work for the maintenance departments and wear janitor's jumpsuits. Other hospitals hire a wide range of technical staff who wear lab coats, monogrammed polo shirts, or dress shirts.

Because there is so little uniformity, it can be difficult for the career field to get the recognition it deserves. Some basic facts are true for most BMETs.

What do BMETs do?

Most BMETs perform several main categories of job function. In general, BMETs are responsible for the support of the technology used in health care. This support assures the safe use of equipment and the best possible patient care. BMETs work closely with medical staff to make sure technology is used safely and effectively.

Ultimately, the *customer* of BMET services is the patient, although many times the patient and BMET are not in the same

place at the same time. Most experienced BMETs define the best BMET as one who thinks of each patient as a relative or loved one. The care and attention one would expect under these circumstances should drive a BMET's job performance.

Who employs BMETs?

Generally, there are three groups of employers of BMETs: hospitals, outside service providers, and the manufacturers themselves. Those who work for the hospital directly or an outside service organization (OSA) or independent service organization (ISO) may appear the same to clinical staff. Some employment issues (benefits, etc.) could be different, but the work-related duties are likely to be similar. Often, when employees work for a manufacturer they are identified as field service representatives or FSRs.

Hospital-employed BMETs generally have the following responsibilities:

- **Equipment repair and troubleshooting** – BMETs fix equipment that is not functioning as expected. This repair may or may not be done "in the shop." BMETs may need to retrieve equipment that has a "broke" sign attached to it, or they may be called to the operating room during a case. Figure 1.1 shows a BMET working on a physiological monitor at her workstation in the clinical engineering shop of the hospital.
- **Preventative maintenance (PM)** – BMETs routinely verify the performance of almost all equipment. This involves evaluating the performance of every aspect of a device and checking or replacing parts to ensure consistent, dependable service. PM may include conducting calibrations and

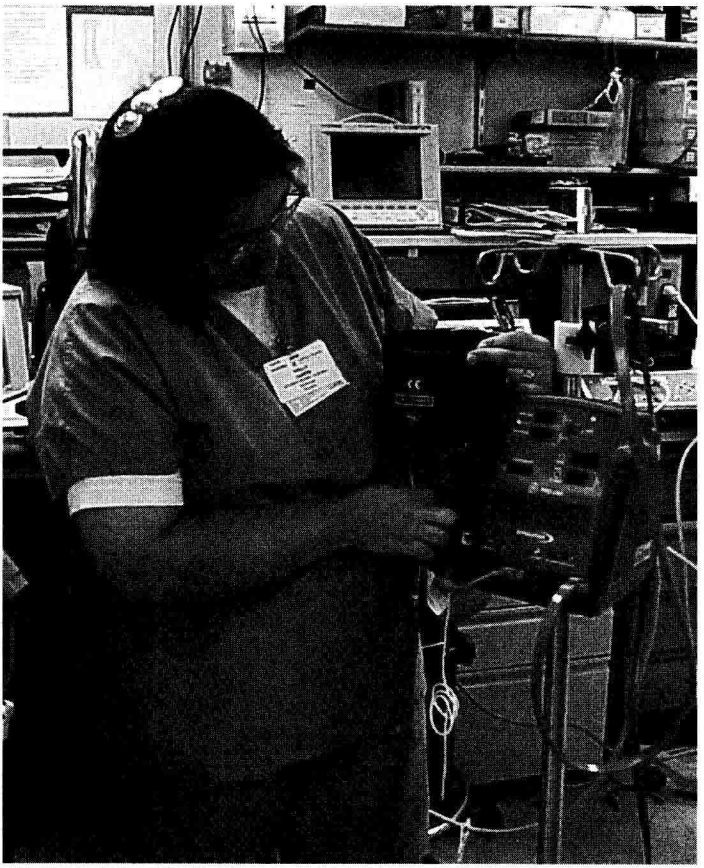

Figure 1.1. A BMET works in the shop on a physiological monitor.

safety checks as well as removing the "white dust" that comes from bed linens, a task that occupies a great deal of the fledgling BMET's time. Performing preventive maintenance is a great way to learn about all the features of an instrument, and the experience can assist a BMET in future troubleshooting. This type of activity is sometimes called *performance assurance*. Figure 1.2 shows a BMET performing PM on a ventilator.

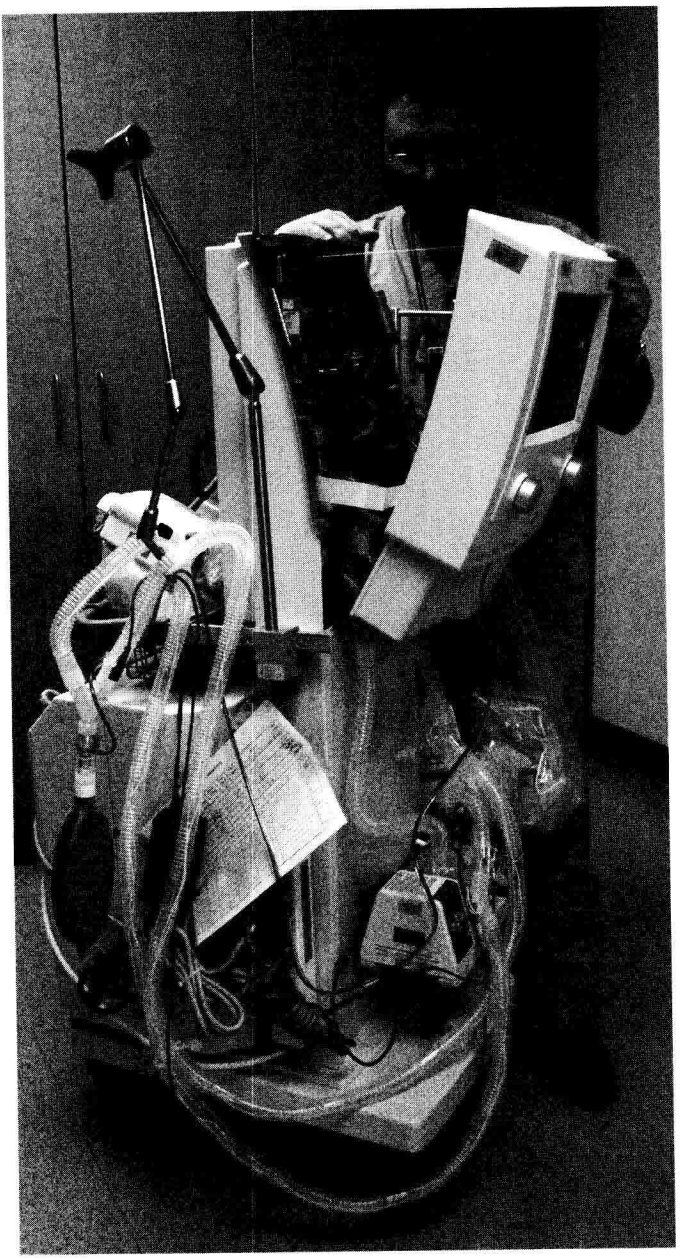

Figure 1.2. A BMET calibrates a ventilator.

- **Staff support** - BMETs provide both formal and informal equipment instruction to many groups including the users of equipment and other BMETs. BMETs may arrange and lead an *in-service meeting* during a staff meeting to introduce a new device and train staff. BMETs also work one-on-one with a staff member. Excellent customer service is vital to effective job performance.
- **Pre-purchase evaluation** - As new equipment (new models or entirely new devices) is considered for purchase, many BMETs are involved in the selection decisions, usually working very closely with the medical staff. As medical technology becomes interwoven with other medical equipment in the hospital, the cross-departmental interactions often fall to BMETs.
- **Incident investigation** - When there are problems with equipment, experienced BMETs are often part of the team that evaluates issues surrounding a malfunction.
- **Incoming testing** - When new devices arrive at the hospital, BMETs must verify that every aspect of every piece of equipment functions properly.
- **Adaptations/modifications** - BMETs are occasionally asked to modify equipment to better medically serve clinical staff as well as better serve a patient with restrictions or limitations.
- **Departmental development/training classes** - Departments have meetings and other activities that must be documented. Documentation of activities is a required departmental activity. Accreditation bodies have a policy that basically concludes: "if it is not written down, it did not happen." In addition, BMETs are often expected to participate in additional training, which is usually device specific and often offered by the manufacturer.

- **Updates** – When manufacturers change or update equipment (for example, software) the BMET installs or makes the necessary changes.
- **Safety board** – BMETs help to set policies and investigate problems, especially regarding hospital process efficiency and staff training. In addition, plans for emergencies include medical equipment, and BMETs contribute to these disaster plans.

Non-hospital-employed BMETs take on a number of the previous responsibilities in addition to some of the following functions:

- **Telephone support** – Some BMETs answer phone lines to assist users of equipment as well as technicians who are attempting to make a repair.
- **Sales** – Some BMETs work for a manufacturer, outside service organization, or repair depot as a salesperson.
- **New equipment design** – Some BMETs work for a manufacturer and design new devices.

In general, most hospital-based BMETs work "hospital" hours: 7 A.M. to 3:30 P.M. (or something like that) Monday through Friday. While some institutions do have shifts on weekends, most shops do not staff nights or weekends. Policies for "on-call" coverage vary, although most hospitals easily deal with problems "off hours" with minimal weekend and night trips back to work.

Table 1.1 shows the standardized definitions for people who support medical equipment technology. Levels have been identified based on years of experience, and this table also explains the higher education requirements that are most common (although not absolutely required).

TABLE 1.1. *AAMI job descriptions*

BMET I - An entry-level or junior biomedical equipment technician (BMET). Works under close supervision. Performs skilled work on preventive maintenance, repair, safety testing, and recording functional test data. Not certified. Usually has less than four years of experience.

BMET II - A BMET who usually has a two-year degree or higher. Has good knowledge of schematics and works independently on repairs, safety testing, and preventive maintenance (PM). Maintains records, writes reports, and coordinates outside repairs. Average experience is eight years.

BMET III - A highly experienced or specialized BMET usually having an AS (two-year) degree or higher. Has substantial experience and may be certified (CBET). Does highly skilled work of considerable difficulty. Has comprehensive knowledge of practices, procedures, and types of equipment. Average experience is 12 years.

Equipment Specialist - A highly specialized BMET having special training or equivalent experience in lab equipment (LES) or radiology equipment (RES). Usually has an AS (two-year) degree or higher. Performs highly skilled work of considerable difficulty and may hold certification as CLES or CRES.

BMET Supervisor - A BMET who supervises others. Has a significant amount of training, education, or equivalent experience. Most have a BS (four-year) degree or higher. Schedules and assigns work to subordinates, but also continues to do highly skilled repairs. Has comprehensive knowledge of practices, procedures, and types of equipment. Average experience is 13 years.

Clinical Engineer - A graduate engineer holding a BS, MS, or PhD. Performs engineering-level work of considerable difficulty. Has the ability to modify devices and do analysis of devices and systems.

Clinical Engineering Supervisor - A clinical engineer who supervises BMET/peer/subordinate clinical engineers; may also supervise equipment specialists. Usually degreed engineer at BA, MS, or PhD level. Average experience is 21 years.

Director/Department Manager - Most are educated or experienced as clinical engineers or BMETs, but others may be trained in administration or business or have extensive health care supervisory experience. Most have a significant amount of technical or management experience and the skills to select high-tech equipment and acquire, maintain, and repair equipment. Supervises BMETs, clinical engineers, and support personnel. May also be the chief technology officer or vice president for health care technology.

IT Technologist/Technician - An IT technologist/technician manages projects in the areas of system administration, software development, and network security and provides direct technical support in at least one of these areas.

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Field service representatives

Field service representatives (FSRs) are generally employed by the manufacturer of a medical device or technology. This person represents the company by servicing or supporting (training, for example) a particular device or group of devices at the clinical site. Sometimes these BMETs are called field service engineers, equipment specialists, or customer engineers.

In general, field service representatives perform many of the job functions of general BMETs. The proportion of the time spent on the various facets of the job shifts when FSRs focus on one type or group of equipment. In addition, some FSRs are very specialized as trainers or do mainly repairs and therefore have a very narrow range of duties.

Generally, FSRs are commonly used in such areas as radiology (imaging), clinical laboratory, anesthesia, LASERs, and operating room equipment, to name a few. Most common is imaging and clinical lab since they involve very complex, very expensive equipment that requires in-depth (weeks or months of) training. It is a significant financial and personnel commitment for individual institutions to train people to support a single device (or a few) that one hospital owns. By spreading the technical skills of an FSR over several hospitals, support expenses to the institution may be less. Or, contracting for service may be the only option an institution has to provide a skilled technician who can support the device (irrespective of cost).

Most field service representatives work under a service contract purchased by a clinical facility. Some manufacturers require that service only be performed by their own FSRs. In addition, service contracts can be efficient for the institution because a highly trained person will respond quickly. This may be especially