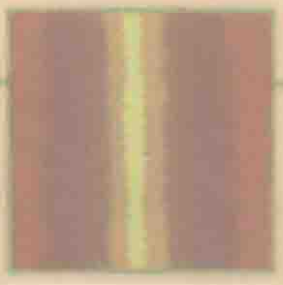

Invasive Monitoring and its Complications in the Intensive Care Unit

ARNOLD SLADEN

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ARNOLD SLADEN, M.D.

Professor of Anesthesiology and Critical Care Medicine,
Associate Professor of Surgery,
University of Pittsburgh School of Medicine;
Director, Surgical Intensive Care Unit,
Montefiore Hospital,
Pittsburgh, Pennsylvania

With 205 illustrations

The C. V. Mosby Company

St. Louis • Baltimore • Philadelphia • Toronto 1990

Editor: Susan M. Gay
Developmental Editor: Elaine Steinborn
Production Editor: Amy Adams Squire
Book Designer: Susan E. Lane

Printed in the United States of America

The C.V. Mosby Company
11830 Westline Industrial Drive, St. Louis, Missouri 63146

Library of Congress Cataloging in Publication Data

Sladen, Arnold
Invasive monitoring and its complications in the intensive care unit / Arnold Sladen.
p. cm.
Includes bibliographies and index.
ISBN 0-8016-5788-1
1. Intravenous catheterization. 2. Arterial catheterization. 3. Urinary catheterization. 4. Patient monitoring. 5. Critical care medicine. I. Title.
[DNLM: 1. Catheterization—adverse effects. 2. Intensive Care Units. 3. Monitoring, Physiologic—adverse effects. WX 218 S631i]
RC683.5.I5S53 1989
616'.028—dc20
DNLM/DLC 89-9467
for Library of Congress CIP

C/RRD/RRD 9 8 7 6 5 4 3 2 1

To Jean
for patience and understanding

PREFACE

Critically ill patients frequently require invasive monitoring so that physicians can acquire the data needed to assist in diagnosis and to provide optimum therapy. The spectrum of invasive techniques now available ranges from placement of urinary bladder catheters to intracranial and intracardiac pressure measuring devices. With every avenue used for invasive monitoring, there are potential hazards and complications that occur not only while the device is in situ but also during its placement and removal. For many patients, invasive monitoring is not limited to a single organ system; indeed, in an intensive care unit, multiple system invasive monitoring is the rule rather than the exception. As the use of invasive devices increases, the complication rates also increase. Iatrogenic problems can outweigh the problems of the primary illness for which the patient was admitted to the ICU. The frequency and quantity of complications from central venous catheterization became so great that the newsletter of the American Society of Anesthesiologists recently included an article by the Central Venous Catheter Working Group, citing a 10% complication rate associated with the 3 million central venous catheters inserted annually in the United States. Many of these complications were related to technique and carried a substantial mortality rate.

This book describes invasive venous, arterial, intracranial, and urinary bladder monitoring. The goals are to review and define the indications for the selection of each monitoring pathway, to describe the correct techniques of catheter placement and removal, and to outline the complications associated with the catheter and its related plumbing occurring throughout the use of the device. This text covers the practical and didactic aspects of invasive monitoring techniques and is designed for use by critical care physicians, house staff, medical students, physician assistants, nurses, paramedical

personnel, and all others who are involved in the care and management of critically ill patients. Hopefully, this text will fulfill the goals listed and facilitate patient management as well as reduce the incidence of iatrogenic complications resulting from invasive monitoring among critically ill patients in the ICU.

Arnold Sladen

ACKNOWLEDGMENTS

I am grateful to John Erlen, Ph.D., of the History of Medicine, Falk Library, and Gloria Rosen, Director of Medical Library, Montefiore Hospital, for their helpful suggestions. I would like to thank the staff of the Medical Photography Department of Montefiore Hospital for their assistance, Elizabeth Cohn for editorial assistance, and Joan Sines-Rieger for preparation of the manuscript. I am indebted to Jan Deakins for rendering the illustrations.

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CHAPTER

1

EVOLUTION OF MONITORING

Monitoring had its genesis in the late seventeenth century, when science became independent of philosophy, when precise measurement and exact methodology became as important to the physician as empiricism had been. In the last three centuries scientific knowledge and understanding of the fragility and complexity of the human body has increased steadily and unbounded. Consequently, monitoring techniques have been advanced and refined. However, what advancements have been made toward better patient-physician communication? Has the advent of sophisticated monitoring equipment and the data derived from it in the intensive care unit (ICU) produced physicians who look only at waveforms and numbers, are remote from the bedside, and ignore the patient?

DIAGNOSIS IN THE EARLY SEVENTEENTH CENTURY

Three centuries ago, the early seventeenth-century physician attended his patient primarily by listening to his narrative and then prescribing therapy.[1] Diagnosis was made by allowing the patient to fully describe his symptoms, when necessary supplemented by interrogative remarks of the physician. This remains the typical method of obtaining a medical history, even in the twentieth century. From the history the seventeenth-century physician would select specific points as indicators of current or even past illness. The physician became skilled in studying the patient's overall physical appearance and behavior pattern, and it was unusual for any physical contact to take place between physician and patient.

We are fortunate to have preserved the case records, correspondence, and prescriptions of John Symcotts, M.D. (1592-1662), who practiced in Huntington, England.[2] A typical example illustrates history and therapy only:

> Mistress Christian Tenum of Cambridge, fifty years of age, could sleep so little that for fifteen years she had scarcely two and only rarely three hours sleep each night. For twenty years she had a pulsing of the arteries and when she first lay down to rest many images of things passed before her eyes. Ringing in the ears. She felt as if a heavy burden of weight was continually pressing down upon the top of her head. She had a feeling of intense heat at the back of the head. She was usually delirious once a day. Pain in the left abdomen. In colic a concentration of wind. Weakness of the back. During her menses (which had stopped five years earlier) her face had swollen, and it was followed by several stools. Three years ago she was striken with paralysis and from this she still has a numbness of the head. A continuous cough. I prescribed diet drinks, a vomit, purgatives, and the spring following a diet drink again, and after that terebinth and other diuretics, upon which she made much bloody water and voided many stones which she dreamt not of before, and so was cured.

In a case history of head trauma in a 20-year-old man with whom interrogation was impossible, the commentary provides a narrative of the patient's behavior coupled with Symcotts's observation and treatment.

From these cases it appears that physical examination was omitted entirely. The simplest of monitoring techniques is not evident, with one major exception. Today, one of the most frequently used monitoring techniques is measurement of urine output, because it reflects cardiovascular and renal systems and the state of hydration. Regarding the preceding head trauma case, Symcotts made specific comments with respect to urine output, noting initial oliguria and subsequent good urine flow. In yet another case presentation both Symcotts and a surgeon named Roland cared for a desperately ill patient for 3 days before the woman made a sign to her husband to inquire about the pain in her abdomen. Only then did the two learned practitioners examine the groin and discover a bubo. The patient died.

It was also not unusual for the physician never to see the patient, but to treat entirely by correspondence.

A letter to Symcotts:

Sir,

I have a great burning pain about the reins of my back which strikes up to the very top of my belly, and a wonderful ill scent arising from my stomach. I do desire your best advice. In my handering for physic I have taken so much all ready and it has done me no good, and therefore I would desire you to send me no physic but some oil or some cooling thing, for I am very sore about my back that I cannot stand upright. The greatest pain of all is my left kidney.

[Unsigned]

William Cullen (1710-1790) an eminent physician of Edinburgh, Scotland, carried out a consultation practice by correspondence and 3000 letters remain to this day.[3] Cullen rose early in the morning, read his letters, dictated his replies until about 9 AM, and then visited his patients. Most letters were attended to within a day. Cullen was one of the first to use a letter-copying device; hence, copies of his original correspondence are still available. The correspondence system had many drawbacks such as delays in the mail, letters misdirected or not arriving, and inadequate information from patients who could not be questioned other than by further correspondence. Cullens's fee for a written opinion was one guinea, a fair sum at that time.

In direct consultation with patients, the seventeenth-century physician invariably assessed physical appearance with the patient either clothed or covered with night attire and coverlets. Observation was limited to the color and expression of the face, the tongue, and the pattern of breathing; and the character of body fluids, blood, urine and stool was assessed. Comments on how the patient sat or lay in bed were recorded also.

Physical contact was limited to palpation of the pulse to assess its character, not rate (Figure 1-1). Feeling the brow with the hand determined fever. Only rarely was clothing removed to allow physical contact between physician and patient.

EDUCATION OF THE SEVENTEENTH-CENTURY PHYSICIAN

Medicine in the seventeenth century was not an exact science but rather a philosophic study. It required extensive thinking of fundamental intellectual patterns, occasionally relative to the current period but mostly stretching back to Galen and Plato.[4]

FIGURE 1-1. Physician checking the pulse of a patient, as painted by Jan Steen in *The Sick One. (Kunsthistorisches Museum, Austria.)*

Achievement of philosophic goals was rewarded only after prolonged university training. In the seventeenth century the only universities in England were those at Oxford and Cambridge.[5] There medicine could be studied but was neither highly regarded nor vigorously undertaken as academic training. Initial graduation with an arts degree was followed by a textual study of Hippocrates (Figure 1-2), Galen, and Avicenna for a degree in medicine (Figure 1-3). Neither of the universities had hospitals in which clinical instruc-

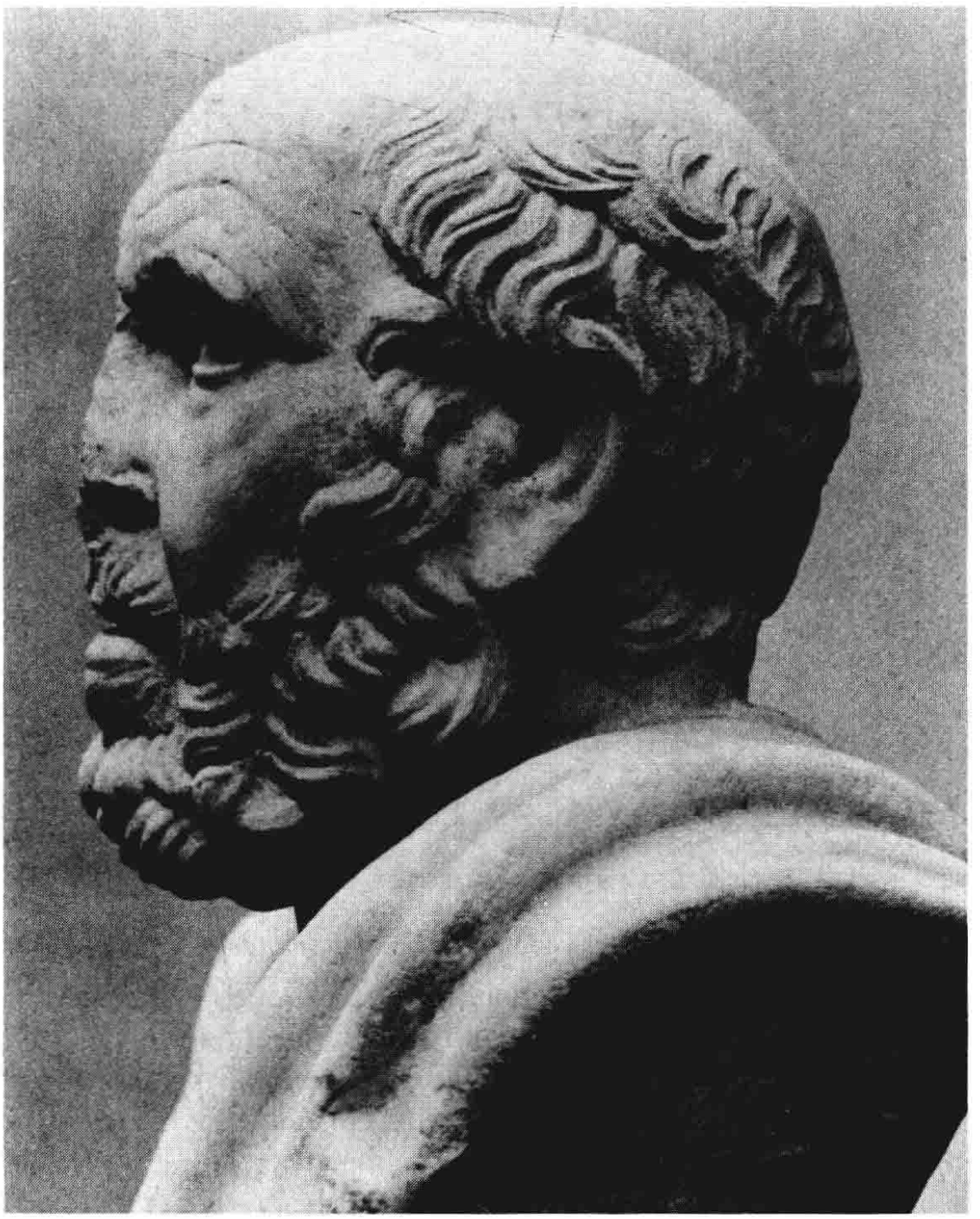

FIGURE 1-2. The *Hippocrates of Ostia*. This remarkable head was discovered in 1940, in an excavation near Ostia, the ancient Roman seaport. It was found in the family tomb of a Greco-Roman physician of the first century; AD. *(From Fishman AP and Richards DW: Circulation of the blood, Bethesda, 1982, The American Physiological Society.)*

tion could be given, and there were no formal arrangements for students to obtain clinical experience with local physicians. Students did not dissect cadavers, and many of their professors had never done so. Although they spent from 6 to 11 years studying ancient medical writings, they could fulfill all requirements for anatomic study secondhand and in 2 or 3 days (Figure 1-4). For these

FIGURE 1-3. Manuscript illustration showing Galen flanked by Hippocrates and Avicenna, from an edition of the works of Galen published in Lyons in 1528. *(National Library of Medicine, Bethesda, Md.)*

reasons many traveled to the continent of Europe, where training in medicine was pursued with both more respect and more vigor. In light of this very formal and textual education, one can understand why physical contact with the patient remained beneath the dignity, social standing, and intellectual behavior of the physician. The surgeon was regarded as a nonphilosopher, a nonacademician, and of lower social standing than the physician. After leaving school at the age of 14, he was apprenticed for 7 years to a master surgeon and then was admitted to the freedom of his company. After this he could begin his own practice.[6] By such time he had acquired considerable manual dexterity and skills and was available to examine the patient and perform operations (Figure 1-5).

The seventeenth-century physician was a man who had considerable social standing, a philosophic university education, extensive theoretic knowledge of medicine acquired solely from his mentor and text. He was also a man who had little knowledge of or experience with patient contact.

FIGURE 1-4. Rembrandt's *The Anatomy Lesson of Dr. Tulp* (1632). *(Mauritshuis, The Hague.)*

LEADERS IN MONITORING FROM THE LATE SEVENTEENTH CENTURY

The latter part of the seventeenth century saw the birth of giants of inquiring thought (Figure 1-6). They sought to elucidate previously unanswered questions by using accurate and precise methods and experimented with physical matter in an effort to satisfy the new era's thirst for knowledge. At last science broke from philosophic thought. The darkness of the Middle Ages was lifting; mental enquiry and experimentation, perhaps stimulated by a general spirit of adventure, ruled the world. Physicians acquired a new independence of thought, no longer bound by narrow, constricted ideas. William Harvey had discovered the circulation of the blood and published his *De Motu Cordis* (Figure 1-7), and Galileo was embarking on a study of exact measurements as a scientific tool (Figure

Text continued on p. 13.