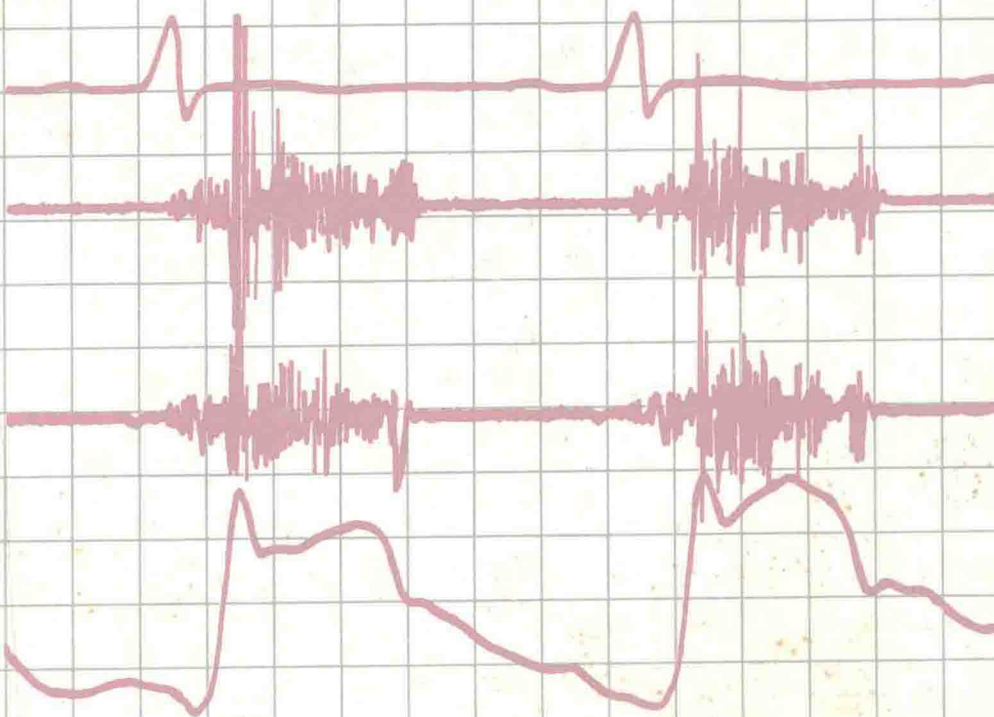
Clinical Phonocardiography and External Pulse Recording

Morton E. Tavel

Fourth Edition



CLINICAL PHONOCARDIOGRAPHY AND EXTERNAL PULSE RECORDING

Fourth Edition

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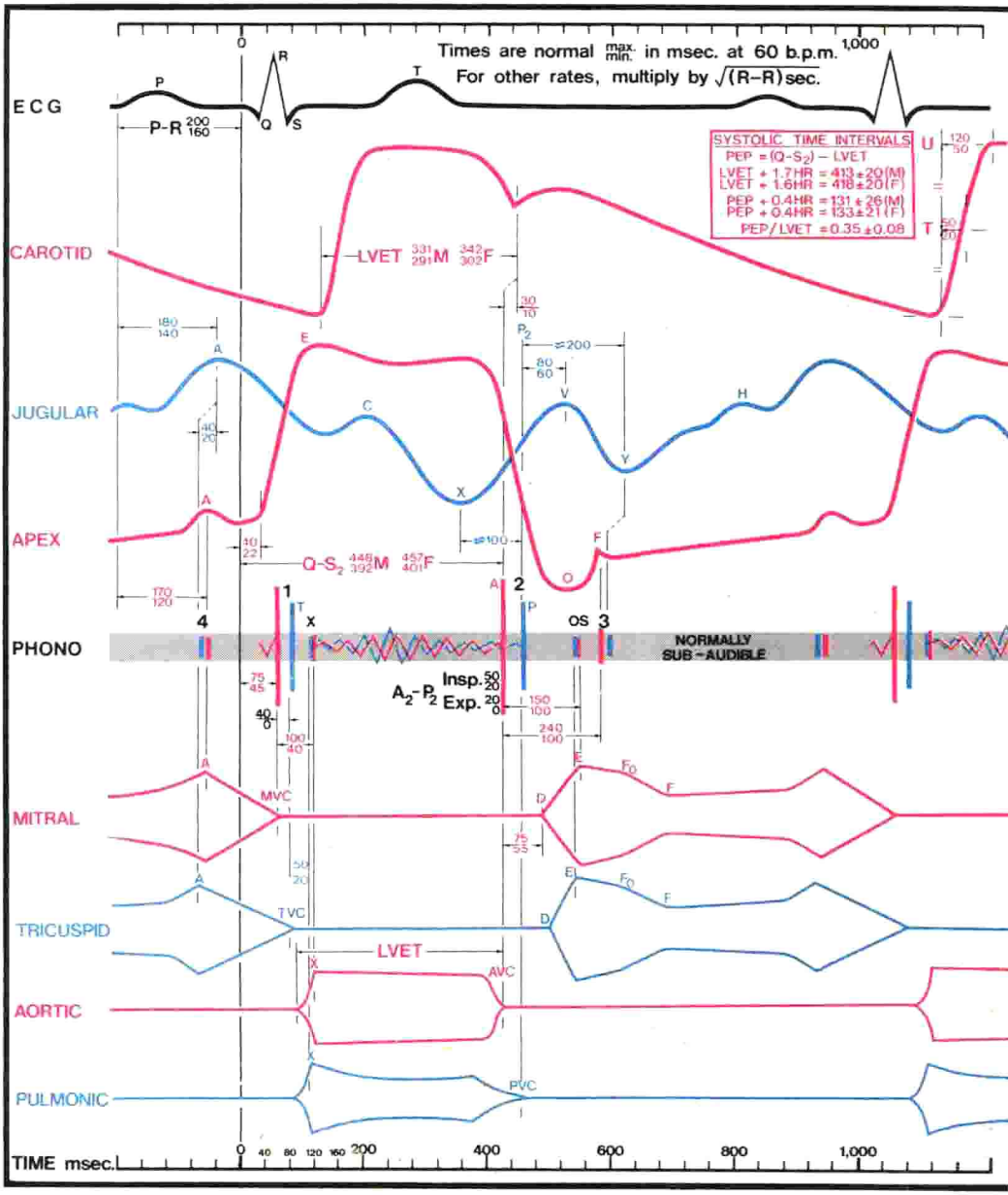
Times are normal max. / min. in msec. at 60 b.p.m.
For other rates, multiply by √(R–R) sec.
ECG
P
R
T
Q
S
P-R 200/160
SYSTOLIC TIME INTERVALS
PEP = (Q-S2) – LVET
LVET + 1.7HR = 413±20 (M)
LVET + 1.6HR = 418±20 (F)
PEP + 0.4HR = 131±26 (M)
PEP + 0.4HR = 133±21 (F)
PEP/LVET = 0.35±0.08
U
T
CAROTID
LVET 331/291 M 342/302 F
JUGULAR
A
E
C
X
V
Y
H
APEX
O
F
Q-S2 446/392 M 457/401 F
≈100
≈200
PHONO
1
2
3
4
T
X
A2
P2
OS
NORMALLY SUB-AUDIBLE
A2-P2 Insp. 50/20 Exp. 20/0
MITRAL
MVC
D
E
F0
F
TRICUSPID
TVC
LVET
AVC
AORTIC
PULMONIC
PVC
TIME msec.
0
40
80
120
160
200
400
600
800
1,000

Clinical Phonocardiography and External Pulse Recording

To
Carole,
Elizabeth,
Robert,
and
Michael

Preface to the Fourth Edition

ALTHOUGH THERE have been few fundamental changes in the field of phonocardiography since the last edition, improved diagnostic accuracy has been made possible through more extensive correlation of sounds and pulses both with intracardiac events and with simultaneous use of advancing understanding of the basic mechanisms of sound production as related to valvar events, e.g., first heart sound splitting and ejection sounds.

In recent years, systolic and diastolic time intervals have been studied so extensively that I have reviewed them in a newly created chapter (11). In that chapter, I have emphasized practical use of these intervals in assessment of valvar and myocardial diseases.

The text has been updated throughout, with deletion of material no longer considered clinically important and with addition of newer, more useful information. Illustrations have been replaced where technically better ones have become available.

I wish to acknowledge the valuable assistance given me by Mr. John Joseph, former Electronics Engineer at Krannert Institute of Cardiology, and by Mr. Francis Andries, Engineer and President, Heart Sound Reproductions, Austin, Texas, in the preparation of much of the technical information concerning the underlying principles of sonic phenomena and their recording. I also wish to thank Dr. Charles Fisch, Director, Cardiovascular Division, and the late Dr. John Hickam, former Chairman, Department of Medicine, Indiana University, for their generous support and encouragement. The Department of Medical Illustration, Indiana University, deserves special thanks for aiding in the preparation of most of the illustrations used in this book. I am indebted to Mrs. Ronald Stewart, Phonocardiographic Technician, who recorded most of the following tracings and provided clerical assistance in the preparation of this manuscript. Finally, I am indebted to the scores of readers, who, through their interest in previous editions, have permitted me to continue the inevitable process of self-improvement that comes with each revision.

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MORTON E. TAVEL, M.D., F.A.C.C., F.A.C.C.P., F.A.C.P.

Preface to the First Edition

DURING THE PAST TWENTY YEARS, phonocardiography has burgeoned into a full-fledged scientific discipline. The technique of external pulse recording, although it has been used and studied for a relatively long time, also has acquired a new significance, resulting from its more exact correlation with internal hemodynamic events and from its relatively new applicability of providing reference tracings for the phonocardiogram. Similarly, cardiac auscultation has undergone a tremendous upheaval, much of which has been fostered by the improved graphic techniques. For reasons which are entirely justified, auscultation remains in the foreground of attention and popularity, and graphic techniques have been relegated to a secondary position. Unfortunately, however, most books refer to phonocardiography *only* as a tool for displaying phenomena which can be appreciated by cardiac auscultation, with the result that usually no serious attempt is made to present phonocardiography as a science in itself. Possibly for this reason, there has been little attempt to summarize current knowledge about the phonocardiographic technique, and particularly about the relationship between the phonocardiogram and the various pulse tracings used for reference. How does one use the graphic techniques to predict hemodynamic events within the heart? What equipment does one need? How can the practicing physician make the best use of his present equipment to acquire specific information about a given patient? In the following pages, I have attempted to answer these questions and to summarize current ideas and information about phonocardiography.

This book is aimed primarily at the physician or student wishing to acquire a working knowledge of the technique and present-day applicability of graphic recordings. It is also aimed at those who wish to learn to interpret these recordings. Hopefully, it will help the individual who wishes to broaden his understanding of the principles of cardiac auscultation. The presentation in this book presupposes, however, a certain basic knowledge of cardiac auscultation and fundamental hemodynamic concepts, such as that which is usually acquired in the early years of medical school.

MORTON E. TAVEL, M.D.

Contents

1 *Introduction*

PHONOCARDIOGRAPHY MAY BE DEFINED as the graphic representation of the sounds that originate in the heart and great vessels. These sounds may be picked up from the surface of the body or, more directly, by placing a suitable apparatus within the heart or vascular structures where sound originates. In this book, we shall be concerned exclusively with the sounds as they are recorded from the body's surface, corresponding to what the clinician hears through an ordinary stethoscope at the bedside. As we shall see, external pulse recording is closely allied with sound recording and might be classified as an extension of phonocardiography. By external pulse recording, we mean the graphic representation of pulsations as they occur on the surface of the body, and the record so obtained usually corresponds to what the clinician sees or feels during an ordinary examination. The term "mechanocardiography" is occasionally used to signify the registration of these latter pulsations.

Sound and pulse recordings are not—and probably never will be—a substitute for the ear or the hand. The human ear generally is far more sensitive and discriminating than a machine. Although many murmurs and sounds can be accurately characterized by phonocardiography, this technique occasionally fails completely to register certain sounds, such as the soft, high-pitched murmur of aortic insufficiency, that are heard by the clinician. Advances in phonocardiographic equipment have, however, improved recording sensitivity enough to render graphic records potentially comparable to—or even better than—the ear (Sakamoto, 1982). The phonocardiogram makes possible the accurate timing of sounds and events—often with the use of simultaneous reference pulse curves—that are too rapid or too subtle to be discerned by our senses. Graphic recording also provides a permanent objective record of events with which subsequent comparison may be made. Such records are especially valuable in following a patient's progress and in evaluating the results of surgery. Thus, although there is considerable overlap between what can be learned by careful physical examination and by phonocardiographic techniques, each of them can supply information not otherwise obtainable. Obviously, it is impossible to totally divorce the two approaches from one another. In the following pages, however, I wish to concentrate heavily on the areas in which the graphic tech-

niques are especially useful. To present a complete picture, however, I shall discuss briefly, where pertinent, many fundamentals of clinical auscultation.

The role of sound and pulse recording as a teaching device cannot be overemphasized. These graphic techniques should be utilized freely in teaching centers, since they allow the student to analyze carefully, at his leisure, the graphic representation of what he sees, hears and feels. Having made the correlation between sensory perception and graphic representation, he can then return to the bedside and reconstruct each time in his mind's eye how each perceptual phenomenon would appear if it were graphically recorded. As this process is repeated over and over, the student becomes progressively more accurate in predicting the graphic appearance, and his need for making such records is correspondingly reduced. It is in this fashion that many of the recent advances in cardiac auscultation have come about. It was not until accurate elucidation of many sounds and murmur characteristics became possible through graphic recording that clinicians went back to the bedside and discovered—probably much to their surprise—that one actually could hear and feel many of the changes described!

Cardiac catheterization and cineangiocardiography, which have provided an accurate diagnosis of both right- and left-heart abnormalities, have added a new dimension to the usefulness of the phonocardiogram and external pulse record in assessing the presence and severity of cardiovascular abnormalities. Although cardiac catheterization generally provides the decisive evidence of the presence and severity of cardiac abnormalities, the external recordings correlate sufficiently well with the internal findings for them to serve, in many instances, as diagnostic tools per se. In this connection, phonocardiography often provides information complementary to that obtained by echocardiography. Once the physician has learned to recognize these correlations, he will be able to predict, with reasonable accuracy, many intracardiac events that were previously unrecognized or uncertain. With this enhanced diagnostic accuracy, he can use the simpler and less painful external techniques to determine when a patient needs more extensive cardiac diagnosis of treatment. Even in those instances where cardiac catheterization is deemed necessary, the knowledge gained beforehand through phonocardiography and other noninvasive studies can lead to much more efficient and fruitful invasive study. For instance, proper invasive measures to elucidate a lesion, such as hypertrophic subaortic obstruction, with careful pull-out pressure determinations and pharmacologic provocative maneuvers will not be overlooked.

In summary, then, the purpose of phonocardiography and pulse recording is threefold: (1) to serve as a teaching device for training and disciplining the senses of sight, touch and hearing; (2) to provide information about underlying hemodynamic events that is not obtainable through physical examination; and (3) to provide a permanent objective record of events with which subsequent comparison may be made.

In this book, I have attempted to approach the subject as the phonocardiographer does in assessing each individual record. He is usually presented with a complex array of sounds, murmurs and pulses and is called upon first to identify what each of these recorded phenomena represents, and then to explain their meaning in terms of their relationship to underlying hemodynamic events. Finally, he must ascertain their importance in the differential diagnosis and in assessing the severity of any lesion known to be present. I have, therefore, treated the subject primarily from the standpoint of analyzing each sound and pulsatory phenomenon, and only in the final pages are the various principal disease entities dealt with—this latter section being designed to serve as a brief summary and point of reference. At the end, a chapter of interpretative exercises for the reader, consisting of unidentified tracings, has been appended—each tracing being followed by the author's discussion and diagnosis. It should be understood that differential diagnostic features are discussed primarily from the standpoint of these graphic techniques. No serious attempt is made to compare the relative value of these techniques with other clinical, laboratory or roentgenologic tools. For example, certain conditions may be more easily distinguished from one another by means of other methods (echocardiograms, etc.) and the phonocardiograms would be of secondary value. Nevertheless, this does not obviate the need for careful analysis of these latter records whenever possible, in much the same fashion that a chest roentgenogram does not eliminate the need for careful physical examination of the chest.

For the sake of brevity, I have avoided long discussions of controversial, theoretical or nonclinical subjects. Where disagreement of uncertainty exists, this has been acknowledged, and I have attempted to fill the void in some instances by expressing my own theories and opinions, with appropriate notice that this has been done. For the interested reader, I have included selected references that support many of the conclusions herein described. I have emphasized more recent publications simply because the older literature already has been well reviewed by McKusick (1958) and Ongley et al. (1960). Besides, the more recent publications generally make reference to the literature published previously on the same and related subjects. Detailed electronic principles underlying the techniques discussed in the book have been simplified considerably and appropriate references are listed.

The following is a list of the principal abbreviations used in the illustrations in this book.*

1 . . . . . first heart sound
2 . . . . . second heart sound
A2 . . . . . aortic component of second heart sound
P2 . . . . . pulmonary component of second heart sound

*These symbols deviate partially from those recommended by the International Subcommittee on Nomenclature in Phonocardiography (Holldack and Luisada, 1965).