INTRAVASCULAR CATHETER

Intra Vascular Catheterization

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FOREWORD

THE EDITOR of this book has undertaken the rather formidable task of accumulating, in a single volume, adequate discussions on the technics and biologic applications of cardiac catheterization. In view of the rapid expansion that has taken place in the past 10 years, it is unlikely that these works could present the varied ramifications of cardiac catheterization in such a way that all issues could be considered completely explored, nor is it to be expected that each contributing author necessarily should be in complete agreement with the others. There does seem to be a place for collected essays on various aspects of cardiac catheterization, and the contributors to this volume have attained eminence as investigators in the subjects which they discuss.

At present the cardiovascular domain has passed from an era of clinical empiricism and dogma into an era of physiologic dominance (and perhaps occasionally dogma). By this time the proper correlations between anatomy and physiology have been largely explored, and it is evident even now that the prediction of precise anatomic detail on the basis of physiologic data often leads to quicksands of error. Conversely, the prediction of the exact clinical picture and the attendant physiologic state on the basis of the anatomic details alone may sometimes lead to a morass of inexactitudes.

The developments in the technic of cardiac catheterization have followed three main pathways, the first as a research tool for the determination of hemodynamic responses to various environmental factors, the second as a diagnostic tool in congenital and acquired heart disease, and the third as a method for the study of metabolism of special organs, including the heart. Researches along such pathways do intermingle, however, and when basic research is combined with diagnostic work, there may be much of value to accrue to each.

Perhaps first on its list of contributions to biologic science is

the role of the cardiac catheter in making possible a beginning understanding of the altered state of the circulation in heart failure. In part by-products of the technic are the significant contributions to the sphere of electrocardiography, in regard to both theory and hemodynamic electrocardiographic correlations.

A number of general problems regarding cardiac catheterization require the scrutiny of all concerned. The first is the problem of adequate instrumentation, to the end that the procedures may be most likely to be technically successful and the data susceptible of accurate analysis; second is the question of the ethics of human experimentation in clinical investigations; third are the possible medicolegal aspects. Some of these problems have been discussed in the recommendations of the Committee on Cardiac Catheterization and Angiocardiography of the American Heart Association. While members of this committee probably would emphasize that they in no way dictate policy or procedures, the recommendations that they have made would seem to deserve thoughtful study by anyone interested in organizing a cardiac catheterization laboratory.

When medical students, laboratory workers and patients are being used either as paid or unpaid volunteers, it behooves the director of the laboratory to be certain that his project is well planned, that his instrumentation is adequate to obtain good records capable of analysis, and that no unnecessary risk exists from the point of view of the nature or the duration of the procedure or the illness of the patient. The procedures as used in the laboratories throughout the country generally would seem to have been remarkably untouched by justified criticism. In the field of diagnosis it should be very clear to the referring physician that if the clinical diagnosis is completely obscure, cardiac catheterization may not reveal the nature of anatomic defects. Likewise, in the case of the severely ill cardiac patient, the routine referral for cardiac catheterization in the hope of thereby obtaining an exact diagnosis and a new therapeutic approach often will be futile.

However, investigations among ill patients may be not only justified but indicated when the hemodynamic data may rationally be foreseen to fill a diagnostic pattern. If our goals be clear, then

professional education, research into the basic disturbances of the circulation and improved care of the patient may go forward, hand in hand, with honor to the method of intracardiac catheterization.

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PREFACE

FOR A NUMBER OF YEARS I have felt the need for a comprehensive text on the entire field of cardiac catheterization. The impact of Frossman's discovery of cardiac catheterization in the field of human circulation has been tremendous. For the first time one can speak about the hemodynamic aspects of the circulation in man which previously were speculation, as much of it was based on circulation in the dog and other animals. The cardiologist of today cannot limit himself to only physical findings, roentgenology, and electrocardiography, but also must keep pace with expanding knowledge of the hemodynamics of the circulation. Each year many newcomers are added to the field in the study of the circulation by cardiac catheterization. Usually they have to grope and search for review of current basic concepts of the many facets of cardiac catheterization.

I first thought of writing the entire text and after deliberation abandoned this idea for one of multiple authorship for the reason that the authors of this book have done some of the pioneer and fundamental basic work in their respective fields or phases. Most of the authors are personal friends of mine whom I have met over the years, while working in this field. Each has expressed his ideas and opinions in these various facets of cardiac catheterization. By necessity there is overlapping and repetition and some disagreement. These, in my opinion, add to the whole concept rather than detract from it.

I am indebted to Payne Thomas and his staff for their patience and co-operation, and to my catheterization nurses, Miss Helen Kleinhenz, R.N., and Mrs. Marjorie McIntyre, R.N., who have made the technique of cardiac catheterization easy, efficient and a pleasant procedure, and to Earle B. Kay, M.D., the surgical part of our team whose constant drive, enthusiasm, skill and friendship has been a great stimulus for me, and finally to my secretary, Jane Di Adario, without whose help this book would never have been finished.

HENRY A. ZIMMERMAN, M.D.

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Chapter I

THE TECHNIQUE OF CARDIAC CATHETERIZATION

By HENRY A. ZIMMERMAN, M.D.

THIS ACCOUNT of the technique of intra-cardiac catheterization is based mainly on our own experiences with a series of approximately 1500 procedures over the last decade. Numerous investigators have contributed to the development of these techniques,[1-76] yet it is our feeling that the existing literature lacks a unified detailed account of the practical aspects of methodology, especially for the newcomers in the field.

HISTORICAL SURVEY

Fritz Bleichroeder in 1905[2] was the first to pass catheters, with no x-ray control, in arteries and veins of dogs and his own veins. At this time no definite purpose was assigned to these experimental procedures. All the same it served to document that catheters could be passed through human veins up to the axilla in the forearm and high inferior vena cava from the thigh without ill effects. In 1912, with the advent of chemotherapy interest was revived in this procedure with the idea of injecting drugs directly into the heart. For this purpose Bleichroeder and Unger studied the effects of inserting catheters in canine arteries and leaving them for several hours. No clot formation or any other complications were observed. Clinical trial is recorded in four patients of puerperal sepsis injecting "Collargol" through a catheter in the femoral artery passed up to the bifurcation of the aorta.

Forssman, in 1929, although not aware of the above work, repeated the procedure with the same object of intra-cardiac injection of drugs. He, also, dissected his own forearm, but has the further credit of guiding the catheter up to the right atrium. This was done under fluoroscopic control in front of a mirror held by

his nurse in the operating room, and he then walked to the radiology department with the catheter in place for x-ray pictures and describes no discomfort connected with the whole procedure. Later, in 1931, Forssman, becoming aware of Bleichroeder's work, pushed the catheter through his own thigh veins. This was done for the purpose of opacifying the heart by injection of radiopaque material. Although he was the first one to obtain such an "angiocardiogram" in dogs his attempts on his own heart remained futile.

In the meantime Kline, in 1930, had already earned the credit of being the first to take venous blood samples from the right ventricle and apply the Fick principle for determination of cardiac output. Such techniques were sporadically practiced by several investigators over the hemisphere, but it was not until 1941 that Cournand and Ranges in this country popularized the procedure for its wide application. The further evolution of this technique by various workers over the world, already referred to, is described in subsequent chapters of this book.

SELECTION OF PATIENTS FOR INTRA-CARDIAC STUDIES

Patients undergoing cardiac catheterization can be mainly divided into two classes.

1. Those patients who are being studied clinically to make a correct diagnosis of either congenital or acquired heart disease.
2. Those patients who are being studied from the research standpoint using intra-cardiac catheterization as a tool for a study of the dynamics of circulation.

The age range of patients on whom we have carried out cardiac catheterization has varied from six weeks up to eighty-five years. Using it as a diagnostic study, the presence of congestive cardiac failure, infection of the upper respiratory passages, frequent and troublesome cough, sudden tachycardia, multiple premature beats or other arrhythmias, and unexplained febrile reactions have led us to postpone the procedure. If studied at all such patients should be handled with extreme care.

PREPARATION OF PATIENTS FOR INTRA-CARDIAC CATHETERIZATION

The patient should be prepared emotionally and psychologically before undergoing the procedure of intra-cardiac catheterization. This can be best done by explaining and broadly outlining the procedure and its purpose and thus gaining the patient's confidence. However, it is equally important to remember not to overdo it by unnecessary details which might add to the patient's anxiety and which in turn may reflect a veno-spasm at the time of the study.

Our usual method of reassuring the patient, if he is an adult, is to show him around the catheterization laboratory and introduce him to the staff. A similar attempt is made in the case of children giving them enough opportunity to become acquainted with us. The patient is informed of the number of needle punctures he is going to receive and their respective sites. To children, putting it as "small mosquito bites" has often worked well. We find it very helpful to explain to the patient that there should be no discomfort connected with the procedure other than the needle punctures, except the possibility of some "flip flops" (premature contractions) inside the chest.

The patient is given 250 mgm of V penicillin t.i.d. the day of catheterization. This tends to prevent the possibility of any local or general infection, and with this the incidence of thrombophlebitis of the arm has been reduced practically to nil, in our hands.

If the patient is undergoing routine diagnostic studies he is given Nembutal grains one and one-half or Seconal grains one and one-half, forty-five minutes to an hour before the procedure. In addition 50 mgm of Pacatol is given orally at the same time. This tends to allay the patient's apprehension and in addition is an anti-fibrillatory agent.[77-84]

If the patient is a small child or an infant, rectal pentothal anesthesia is used. Twenty milligrams of the drug is given per pound of body weight. The patient is given a cleansing enema of saline solution the night before the catheterization. In the last four years we have used this type of anesthesia almost routinely

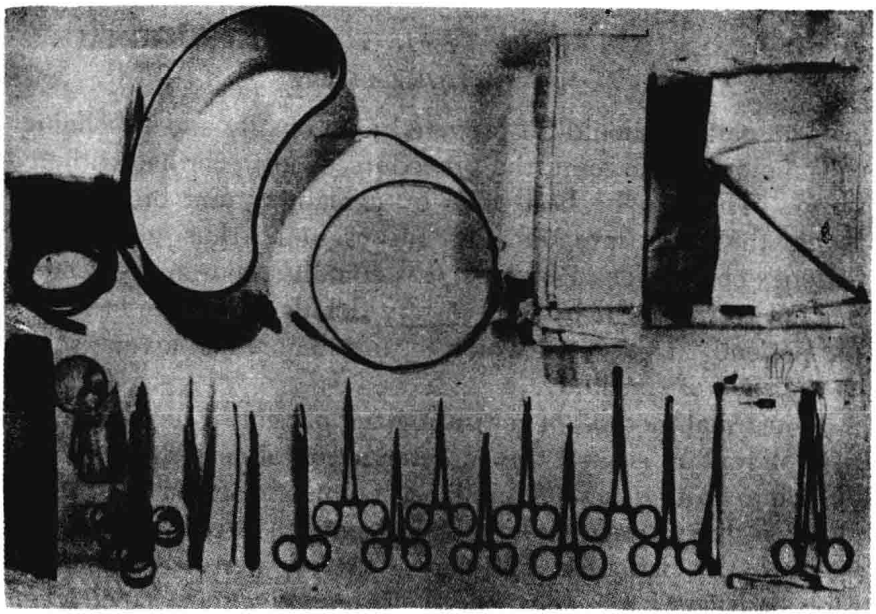

Figure 1. Shows the top of the instrument cart with instruments used in cardiac catheterization.

in all infants and children under the age of three years to our satisfaction in some 280 cases. Occasionally ¼ to ½ of the dose has to be repeated if the procedure is prolonged.

THE INSTRUMENT SET-UP FOR CARDIAC CATHETERIZATION

1. CATHETERIZATION PACKS

Our cardiac catheterization packs consist of the following: See Figure 1
Curved mosquito hemostats (3)
Straight mosquito hemostats with a very fine point (3)
Allis forceps (2)
Tissue forceps (1)
Probe (1)
Needle holder (1)
Bard Parker knife handle with a pointed Bard Parker Blade #11 (1)
Dressing and operating scissors (1)
10 cc syringe-control (1)
Needles—Nos. 20, 23, 25 gage
Small curved cutting needle for skin incision (1)

Black silk suture—4-0
Three way stopcock and rubber tubing connection
Kidney basin (1)
Medicine glass (1)
Sponges

2. DRAPE PACK

The drape pack contains the following: See Figure 1
Large drapes (2)
Towels (4)
Large pillow case (1)
Small pillow case (1)

3. ARTERIAL PACK

The arterial pack contains the following: See Figure 2
Towels (3)
5 cc syringe-control (1)
Abdominal pad (1)
Needles—Nos. 22, 23, 25 gage
Cournand arterial needle BD No. 488 LMR, 18 gage, 2-3/64
Medicine glass (1)

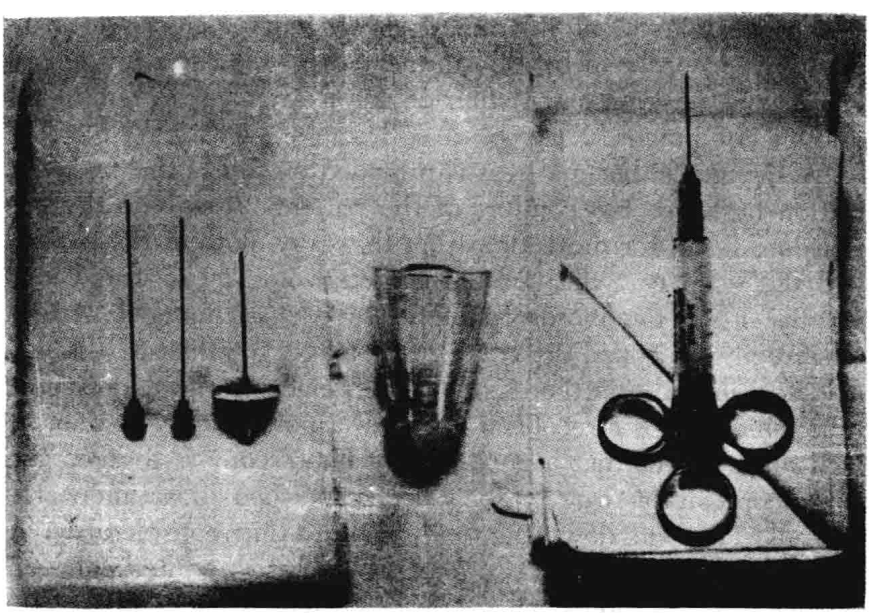

Figure 2. Arterial tray with instruments and packs. The Cournand needle, procaine syringe and medicine glass for procaine are shown.