Coronary Angiography

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In the Medical and Surgical Treatment of Ischemic Heart Disease

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NOTICE

Medicine is an ever-changing science. As new research and clinical experience broaden our knowledge, changes in treatment and drug therapy are required. The editors and the publisher of this work have made every effort to ensure that the drug dosage schedules herein are accurate and in accord with the standards accepted at the time of publication. Readers are advised, however, to check the product information sheet included in the package of each drug they plan to administer to be certain that changes have not been made in the recommended dose or in the contraindications for administration. This recommendation is of particular importance in regard to new or infrequently used drugs.

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Preface

I began my catheterization work in 1961, when I joined the staff of the cardiac laboratory directed by Dr. Edison Otero at the Pabellón de Cardiología Luis H. Inchauspe of the Hospital Ramos Mejía, Buenos Aires. About 1962 we introduced the left heart catheterization technique as a routine procedure in Argentina.

In 1971 I moved to the Hospital Italiano of Buenos Aires as director of its cardiac laboratory, where my active work in coronary angiography began with the help of Dr. Carlos Fiore, Dr. Carlos Garlando and Dr. Alberto Tamashiro. Two old friends from the Hospital Ramos Mejía soon joined our staff: Dr. Hugo Baglivo and Dr. Miguel Del Rio. Their dedicated work allowed me to set aside the routine of the catheterization room and to work full time on the radiological and scientific aspects of the laboratory. It also enabled me, during the last 2 years, to write this book.

If cardiac catheterization was the key that in Andre Cournand's hands opened the door to physiopathological knowledge of heart disease, without doubt coronary angiography was the key that in the hands of Dr. F. Mason Sones, Jr., opened a new stage in the knowledge of coronary artery disease.

As this is the heart disease most often found in the adult, general practitioners as well as cardiologists should indicate coronary angiography with increasing frequency in order to be able to give optimal medical care to their pa-

tients. Thus, more than half of the catheterizations that are performed today are selective coronary angiograms.

Since text books about coronary angiography are scarce, we thought a book such as this one would be useful to our colleagues: a book about coronary angiography in which not only its technique but also its usefulness and limitations in the *medical* as well as in the *surgical* treatment of ischemic heart disease were thoroughly discussed. Therefore this book is aimed not only at physicians involved in catheterization procedures, but also at clinical cardiologists.

Over the last 8 years our primary interest has been the study of the hemodynamic and angiographic features of ischemic heart disease. The research performed in our laboratory relative to left ventricular function in ischemic heart disease and to the correlation between coronary angiography with the clinical subsets of ischemic heart disease and the necropsy findings allowed us to obtain, in recent years, the four major awards given to cardiology research in Argentina: the biennial Sociedad Argentina de Cardiología 1975–76 award; the biennial Rafael A. Bullrich–Academía Nacional de Medicina 1976–77 award; the biennial Cordic Foundation Catalina G. de Barón—1976/77 award; and the Luis Sívori award of the University of Buenos Aires—Medical School in 1978.

This is the first time this research is being presented to the medical reader. Also published for the first time are the concepts of *arterial* and *myocardial instability* and the concepts of *appropriate* and *inappropriate infarction* used to evaluate the risk to the patient according to the coronary angiographic findings.

The experience obtained from the 12,000 procedures performed so far in our laboratory and the background in clinical cardiology that I acquired between 1956 and 1970 at the side of Dr. Blas Moia, one of the great master teachers of Argentine cardiologists, appears together with this research work throughout this text.

The book begins with the fundamentals of indirect radiology. We try to explain why and how it is possible to obtain with cine recording a quality that approaches that of large films, and what are the most common pitfalls when this quality is not obtained.

Next, coronary angiography is analyzed along with the methodology of evaluation that we follow in our laboratory.

We believe that coronary angiography is an *invasive* and *expensive* diagnostic procedure. Hence, we regard its primary utility to be its use as a diagnostic tool preliminary to revascularization surgery in high-risk patients with ischemic heart disease. Conversely, its indication for diagnostic and prognostic purposes should, in our opinion, be very selective.

As a consequence, the last and largest area of concentration in this book deals with the indications and limitations of coronary angiography and offers a critical appraisal of direct revascularization surgery, duly emphasizing its many controversial aspects.

In order to evaluate the risk to the patient, the clinical classification of ischemic heart disease is discussed, as well as the noninvasive procedures that

enable characterization of the high-risk subsets of ischemic heart disease, since those subsets are the most straightforward indications for coronary angiography and bypass surgery. Since coronary angiography and revascularization surgery are also clearly indicated for patients who have angina that is not manageable with medical treatment, we felt it necessary to discuss what is in our opinion an optimal medical treatment of ischemic heart disease.

Last but not the least, it should be remembered that no diagnostic procedure is perfect. Therefore, the limitations of coronary angiography are thoroughly discussed.

This book, as every scientific-technical work of today, is the result of teamwork. The dedication of our nurses, technicians, and secretaries has always been beyond the collaboration that could be expected of them. In the last years they dedicated a good part of their lives to our laboratory; as a consequence, our gratitude is as deep as their dedication.

The help, encouragement and sustained support received from Dr. Francisco Romano, Head of the Cardiological Department of the Hospital Italiano, was fundamental to the writing of this book. Our fellows contributed to the writing of this book with their intensive, responsible work. Two of them, Dr. Dionisio Herrera and Dr. Jorge Rincón Huerta, whose competence and dedication are outstanding, made decisive contributions in several chapters.

The author also wishes to acknowledge the contribution to Chap. 22 of his very good friend Dr. Carlos Bertolasi, who gave him the unpublished results of his follow-up of patients with unstable angina updated to 1979.

ACKNOWLEDGMENTS

We wish to express our gratitude to the father of coronary angiography, Dr. F. Mason Sones, Jr., on this twentieth anniversary of the performance of the first selective coronary angiograms. Though we have not had the honour to work in his legendary Cleveland Clinic B-10 (today Desk 25) where cine coronary arteriography was born, in our frequent visits to his laboratory we were received with the modesty, generosity, and sympathetic enthusiasm that characterizes those who dedicate their lives, beyond personal convenience, to an intensive work for the progress of science and the welfare of human beings. His advice and critical appraisal of our work have had a decisive influence on the performance of our laboratory.

Our gratitude is also extensive to Dr. Melvin P. Judkins and Dr. Winston Mitchell from the Cardiovascular Laboratory of the Loma Linda University Medical Center, who gave us many valuable ideas and much technical assistance.

The publication of this book in the United States was possible only with the dedication, patience, and help of J. Dereck Jeffers, Moira Lerner, Tom LoPinto, and Jeanne Skahan, as well as other staff members of the Health Professions Division of McGraw-Hill. This support is even more valuable considering that they had to work with an author who lives more than 5000 miles from New York.

We wish to thank Mrs. Silvia Capasso, who, typed our manuscripts, draft after draft, and Mrs. Margaret Kothe, who not only copy-edited the manuscript, but who also had the unsurmountable task of translating it from our "spanglish" into proper English.

The quality of the photographs obtained from our cine frames should be credited to Mr. Hugo Busani, Head of the Medical Photography Department of the Hospital Italiano.

If this book contributes to the spreading of knowledge about coronary angiography and to the definition of its indications, as well as those for medical and surgical treatment of ischemic heart disease, the long hours during its writing that I could not dedicate to my wife and daughters will have a meaning for them, because they will share my satisfaction.

Guillermo Pujadas

Contents

Chapter 1

Technique of Coronary Arteriography

Between the late 1940s and the early 1950s the first coronary arteriograms were made by Radner [1] and others with the *flooding technique*, a method which consisted of injecting a 50-mL bolus of contrast medium into the aortic root over a period of 1 or 2 s. This crude technique was later refined; so that the medium would selectively penetrate into the coronary arteries, the cardiac output was lowered by increasing the pleural pressure [2] or by bringing about momentary cardiac standstill with acetylcholine [3].

The technique was further refined by injecting the contrast medium only during diastole (*phasic techniques*) [4], since in systole, when the left ventricle emptied, the material was easily washed out from the aortic root. To further ensure avoidance of this phenomenon, a balloon was used for momentary occlusion of the aortic root [5].

These techniques were abandoned because they were risky and the opacification of the coronary arteries was often incomplete. It was obvious that more selective opacification of the coronary arteries was needed. The semiselective procedure proposed by Sven Paulin [6] was then tried. To this end a polyethylene catheter with a double loop that had several side holes was introduced by means of the Seldinger technique and placed over the sinuses of Valsalva. Perhaps the best examples of this technique may be observed in the book published by Dr. Anton Düx [7] in Germany in 1967. It is obvious, upon examination of his plates, that the method cannot compete with the already well-established selective approach. Therefore in the late 1960s all the nonselective or semiselective approaches were abandoned. Only in small babies and children does good aortography

achieve an adequate opacification of the coronary arteries.

By 1957 it had become evident that selective catheterization of the coronary arteries was needed to obtain satisfactory images. This technique was first used in 1958 by F. Mason Sones, Jr., in the Cleveland Clinic, Cleveland, Ohio [8].

At the present time coronary arteriography is performed exclusively through the selective catheterization of each coronary ostium, injecting into them small quantities (from 4 to 10 mL) of radiopaque media. In most coronary arteriograms the Sones or Judkins technique is used.

THE SONES TECHNIQUE

A catheter designed by Sones is utilized [9]. Its shaft is 2.7 mm wide (No. 8 French catheter) and its distal 4 cm thins out to a 1.8-mm diameter (No. 5.5 French scale). This catheter is pliable and has no "memory" (fixed preshaped curve). The curve in its tip is made by introducing a wire in its lumen, but it can be easily modified during the catheterization (Fig. 1-1).

Besides its distal hole it has lateral holes that facilitate the injection of dye at high speed, making it possible to carry out the ventriculogram with the same catheter. However, if the blood pressure through the catheter is being continuously monitored in order to determine whether the catheter is wedged in a coronary artery, the lateral holes are a distinct disadvantage. Even though the tip may be wedged in the artery, a good pressure recording may be obtained because of the lateral holes (Fig. 1-2). Conversely, if there is only a terminal hole and the catheter is wedged, the pressure is very much damped and falls to near zero. Thus, by monitoring arterial pressure, the physician knows immediately when this potentially fatal situation is present.

Figure 1-1 Sones catheter. The thinning out of its distal tip is shown. Notice also that besides the terminal hole it has lateral ones.

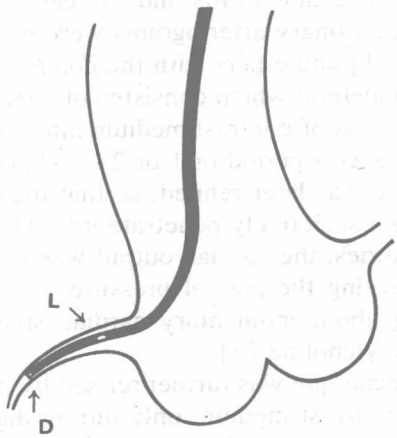

Figure 1-2 The distal tip of the catheter *(D)* occludes the coronary artery. A lateral hole *(L)* is in a zone of the artery proximal to the obstruction where the artery diameter is greater; hence it is not obstructed by the catheter, and through the lateral holes it is possible to get a good pressure tracing.

This problem is not so important, however, with the Sones technique because even the injection is performed under continuous fluoroscopic monitoring; hence it is easily observed when the catheter penetrates too far into a coronary artery.

This occurs more frequently in the right coronary artery because there the catheter penetrates more directly than in the left, where it must usually follow a curve over the sinus of Valsalva (Fig. 1-3). Because of this curve and the flexibility and lack of memory of the Sones catheter, it is unlikely that the catheter penetrates more than 2 or 3 cm into the left coronary artery.

In order to introduce the catheter into the arterial system the brachial artery is dissected 1 cm above the elbow with local anesthesia

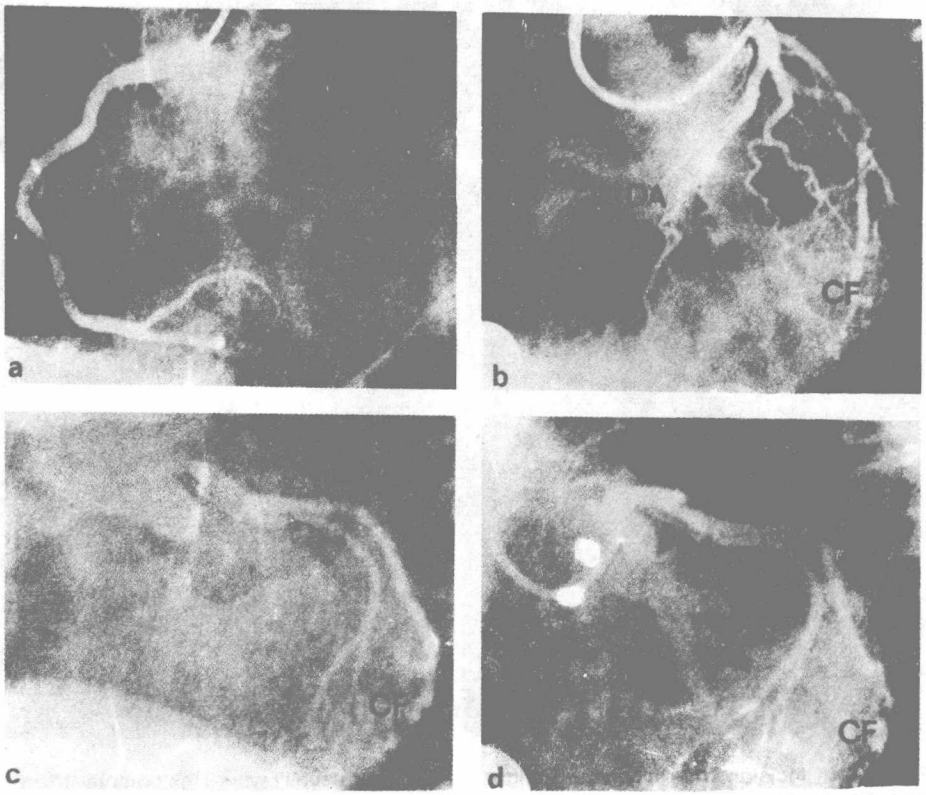

Figure 1-3 The Sones catheter penetrates directly and often deeply into the right coronary artery (a). On the other hand, when catheterizing the left coronary artery, it usually bends over the noncoronary aortic cusp and its tip sits at the orifice of the left coronary artery without penetrating into the vessel (b). Therefore the position of the catheter is unstable. During the injection it is sometimes dislodged from the ostium and falls into the sinus of Valsalva (c); the opacification of the coronary artery at such times is only fair. When the catheter stays in the ostium during the entire injection, the opacification is correct (d). Photos (c) and (d) do not show the left anterior descending because it is completely obstructed (compare with b). Photos (a) and (b) were taken with a cesium iodide intensifier and (c) and (d) with a cadmium sulfur intensifier. Note the better contrast and resolution of photos (a) and (b).

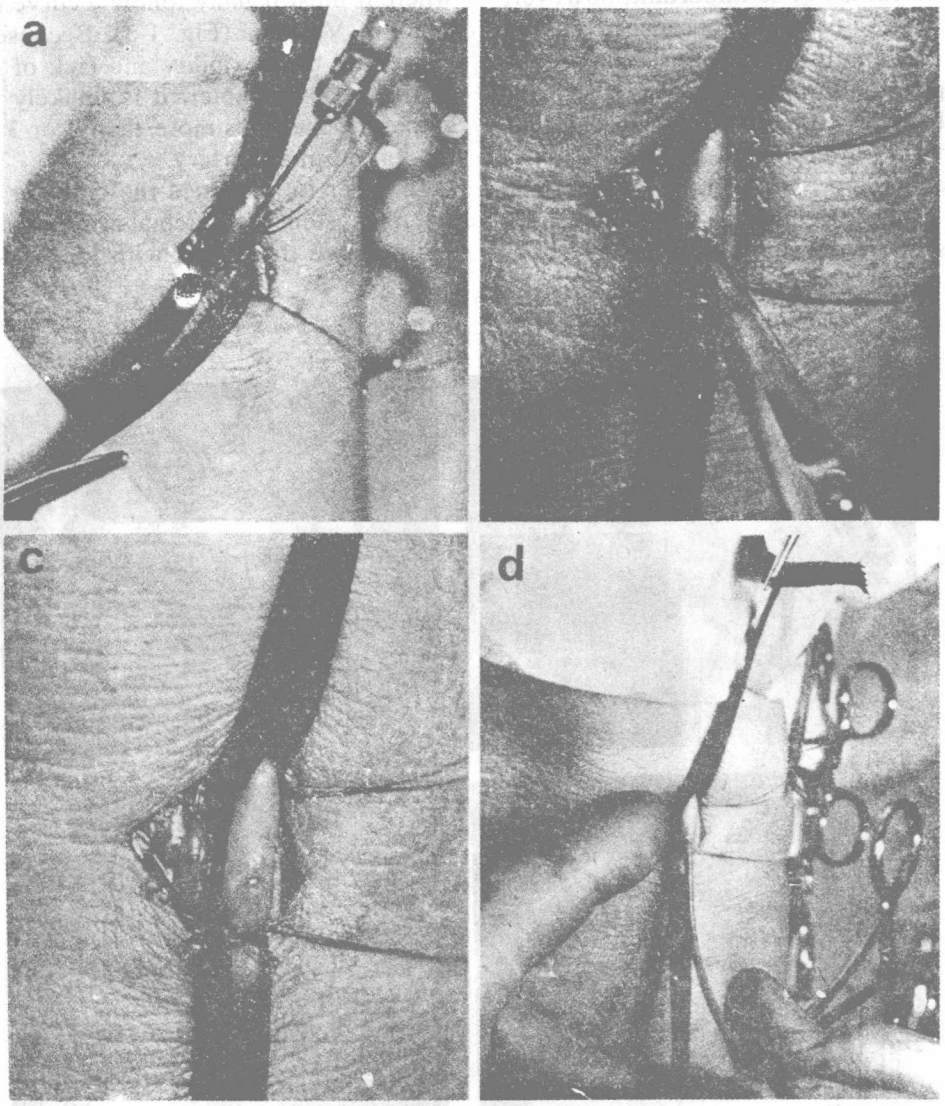

Figure 1-4 Incision in the skin at the height of the elbow, usually where the brachial artery is best felt. (a) Heparin injection in the artery. Tightening the proximal tape and loosening the distal. (b and c) Arteriotomy performed with very sharply pointed scissors, widening the small hole made by the needle when the heparin was injected. (d) Introduction of the catheter into the artery. Observe that the distal tape is pulled with the middle finger and thumb; the index finger fixes the artery. The catheter is introduced with the right hand. An assistant holds the proximal tape to avoid hemorrhage.

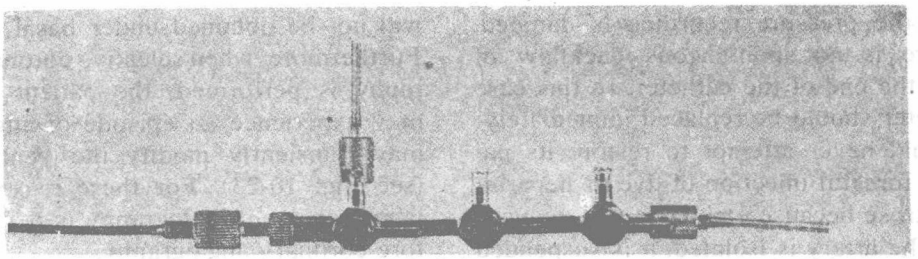

Figure 1-5 Manifold with the rotating adapter incorporated. Teflon tubes connect the pressure gauge (P) and the angiographic injector (IN).

(Fig. 1-4a). The catheter has been previously connected to a rotating device to permit its free rotation during the catheterization without disconnecting it from the flushing and pressure lines that are connected through stopcocks placed behind the rotating adapter. The stopcocks should be welded together to avoid accidental disconnection during the procedure.

It is advisable to use commercially available manifolds with Teflon cores since the risk of leakage is less with them, and as they resist high pressures, the contrast material for performing the ventriculography may be injected through them (Fig. 1-5). During the injection the pressure transducer should always be vented to air to avoid its irreversible damage since the pressure may be transmitted through the Teflon cores. If metal manifolds are used, they should be disassembled after each catheterization and after thorough cleaning should be lubricated with high-vacuum silicone grease.

The catheter should be permanently filled with heparinized dextrose or contrast material, both of which have anticoagulant properties. If there is leakage in the system, blood may enter into the catheter and a clot of fibrin may be deposited in its tip (Fig. 1-6) which if embolized into a coronary artery, may well cause a myocardial infarction.

When there is a clot in the tip of the

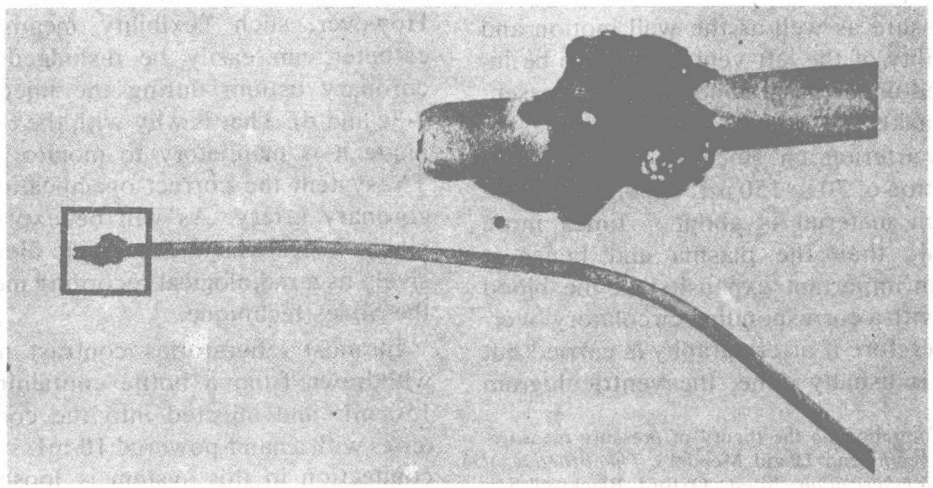

Figure 1-6 Tip of the Sones catheter with a clot of fibrin around the lateral hole.