SECOND EDITION

GASTROINTESTINAL ANGIOGRAPHY

REUTER AND REDMAN

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FOREWORD

Five years ago, *Gastrointestinal Angiography*, by Stewart R. Reuter and Helen C. Redman, initiated the Saunders Monographs in Clinical Radiology series. To the delight of authors, editor and publisher, it was rapidly and widely accepted as an authoritative source of information about an area of clinical medicine that had become increasingly important. In addition, the book set a standard of excellence for subsequent volumes in the series.

Now, in the Second Edition, the authors have added to the basic discussion of the subject newer developments in application and technique of gastrointestinal angiography, including interventional angiographic procedures, and thus once again have prepared an up-to-date, definitive monograph for radiologists, gastroenterologists and abdominal surgeons.

Dr. Reuter is now Professor and Vice Chairman of Radiology at the University of California, Davis and Professor of Radiology at the University of California, San Francisco. Dr. Redman is Assistant Chief of the Department of Radiology at Mt. Zion Hospital in San Francisco. Both have contributed to the development of techniques of gastrointestinal angiography and are now widely recognized as the leaders in the field. It is a pleasure to welcome this Second Edition of the first Saunders Monograph in Clinical Radiology, in anticipation that it will be as well received as its predecessor. The authors have again provided us with a remarkable opportunity to keep abreast of a rapidly changing field.

E. JAMES POTCHEN, M.D.

PREFACE

The years between the publication of the first and second editions of this monograph have witnessed the rapid development of trends that were discernible, though inchoate, at the time of the initial writing. Perhaps the most important has been the improved accuracy of noninvasive diagnostic imaging modalities in the abdomen. These techniques have placed angiography in a proper, if diminished, role in the diagnosis of visceral disease. In the past, angiography was used too frequently as a diagnostic screening method in the pancreas, the liver and throughout the abdomen generally. As late as 1973, a widely respected chairman of a university surgery department stated that all patients with suspected carcinoma of the pancreas should have pancreatic angiography. Now this has changed. Most patients coming to pancreatic angiography have had a diagnosis established; pancreatic angiography is being done primarily to determine resectability of carcinomas and to establish a diagnosis in those few patients in whom the diagnosis remains equivocal. Another major change has been the rapid expansion of therapeutic angiography in all parts of the body. In the abdomen, this has been primarily in the control of massive gastrointestinal hemorrhage.

The second edition has been modified to reflect these changes. Although the disease orientation of chapters has been maintained, those diseases in which the use of angiography has increased or become better defined have been expanded. Those diseases in which angiography now plays a smaller role have been contracted. Throughout the book, the number of illustrations has been increased and improved.

Finally, there has been a general request for the inclusion of a section on superselective catheterization technique. Although these techniques were adequately developed at the time of the first edition, a description was excluded because it was felt that most physicians to whom the book would appeal would not perform or have interest in these examinations. We underestimated the sophistication of our audience and therefore have added a section on superselective angiographic technique. This section is to be read with the caveats that the selection of a particular angiographic technique is personal and that techniques are difficult to describe. Therefore, although we have described techniques developed and used by other angiographers, those receiving the greatest emphasis have been our own.

We were delighted with the response to the first edition and with the knowledge that it filled a gap in the angiographic literature. The second edition is directed toward the same audience as the first. We hope the field of visceral angiography has now stabilized to the point where this edition will not become obsolete so rapidly.

CONTENTS

Chapter 1

EQUIPMENT AND TECHNIQUE USED IN CATHETERIZATION OF THE VISCERAL ARTERIES

Selection of the proper catheterization equipment and development of a facile catheterization technique are essential in obtaining a successful angiogram, in decreasing the discomfort of the patient and in keeping angiographic complications to a minimum. This chapter is detailed because an overall discussion of catheterization equipment and technique is not easily available to the beginning angiographer. In this discussion the principles involved in selectively catheterizing the visceral vessels are stressed. Recommendations of the equipment of one or another manufacturer are specifically avoided. By stressing the principles that are important for producing excellent angiograms while minimizing the complications of the procedure, the equipment and technique acceptable to most visceral angiographers can be described. Varying experience, of course, leads to a variety of techniques, and other methods are also acceptable in many instances.

CATHETERIZATION EQUIPMENT

Catheterization of the visceral arteries is done exclusively by the percutaneous transarterial technique devised by Seldinger (1953). The necessary equipment consists of a needle, a guide wire and a catheter.

These must be compatible with each other so that there is a good fit between needle and guide wire, and between guide wire and catheter. The units of measurement for the catheterization equipment are confusing since they are given variously in inches, millimeters or the French scale. Needle sizes are generally stated as Stubs needle gauge, guide wires as thousandths of an inch and catheters as French, inches or millimeters. Both inner and outer diameters for catheters must be known. Table 1–1 gives the conversion equivalents for commonly used guide wire and catheter sizes.

While extensive changes have occurred in radiographic tubes and generators during the past 25 years, only relatively minor developments have occurred in equipment for catheterization. The most important change has been the use of smaller needles, guide wires and catheters. The early angiographers used approximately 15 gauge needles, 0.052 inch guide wires and 8 French outer diameter catheters. The needles now used are 18 gauge or smaller, the guide wires are about 0.038 inch and the catheters are 7 French outer diameter or less. The use of smaller equipment is one of the most important factors in the decreased incidence of complications with angiography today compared with 15 years ago.

TABLE 1–1. Conversion Table for Measurements of Guide Wires and Outer Diameters of Thin-walled Catheters Commonly Used in Visceral Angiography

GUIDE WIRES		
Inches	*Millimeters*	*Pass Through Thin-walled Needle Gauge*
.028	0.711	19
.038	0.956	18
.045	1.143	16
.052	1.321	15

CATHETERS		
French (mm diameter × 3)	*Inches (diameter)*	*Millimeters (diameter)*
3	.039	1.00
4	.053	1.34
4.1	.054	1.37
5	.065	1.67
5.3	.070	1.78
6	.079	2.00
6.3	.083	2.11
6.6	.087	2.20
7	.092	2.33
7.2	.094	2.40
8	.104	2.67
8.4	.110	2.80
9	.118	3.00

Needles

The needle generally used for arterial puncture in the Seldinger method has two parts—an outer, blunt cannula and an inner, pointed trocar. For adults, the thin-walled 18 gauge needle is used; for children, the thin-walled 19 gauge. Conventional thick-walled needles should not be used in angiography. The use of a smaller thin-walled needle causes a smaller puncture hole in the artery and still permits passage of the same diameter guide wire. Several types of trocars are available. Some are two-piece, and others are single. Most trocars are beveled, but some have a central point. The bevel or point should be short. No difference exists in the amount of arterial damage caused by short-bevel or central-pointed needles.

Guide Wires

The guide wire has two basic functions. First, it provides support for passage of the catheter through the soft tissues at the puncture site, through the arterial wall and into the arterial lumen. Second, it passes from the puncture site into the abdominal aorta, providing a path for the catheter to follow through atherosclerotic and tortuous iliac arteries. Both of these functions are extremely important in preventing the complications of angiography, most of which occur at the puncture site or in an atherosclerotic, tortuous iliac artery. The standard guide wire is straight and has a soft, flexible end measuring about 1½ inches. Two wires are present inside the coil. One, with a very small diameter, extends from tip to tip and is welded at both ends. This is the safety wire, which should be part of all guide wires. Its development has prevented breakage of guide wires in the patient, a complication of angiography in the past (Dotter et al., 1966). The second, thicker wire fills the remainder of the coil and provides stiffness to the body of the guide wire, which supports the catheter during its introduction into the artery. Without this support, the catheter would buckle, the guide wire would kink and the artery might be torn. The stiffening wire should be tapered as it approaches the flexible end so that there is a smooth transition between the stiff body and the soft end of the wire. The largest diameter guide wire that passes freely through the puncture needle should be used, both to provide maximum support and to allow passage of the largest possible catheter end hole. For a thin-walled 18 gauge needle this is a 0.038 inch wire (see Table 1–1). Many shapes and diameters of guide wires are available. Most of these have been designed to advance through tortuous iliac arteries, and their design and use are discussed under catheterization technique.

Catheters

The catheter materials used for angiography are polyethylene, polyurethane and polytetrafluoroethylene (Teflon). These plastics are generally made radiopaque with barium, bismuth or lead salts. In the early days of angiography, many examiners used nonopaque catheters because the catheters were frequently positioned in the aorta without the benefit of fluoroscopy. With the currently available equipment, no catheter should be positioned in the aorta or one of its branches without image-intensified fluoroscopic monitoring. There is, therefore, no longer a place for nonopaque catheters in visceral angiography.

Of the three types of catheter material mentioned, polyethylene has some advantages over the other two for visceral angiography. It is easy to shape and, therefore, allows the angiographer a great deal of flexibility in designing a shape suitable for the catheterization problem at hand. This is particularly important in superselective angiography. Polyethylene not only has good torque control but also is flexible enough to avoid damage to the intima. Also, even thin-walled polyethylene catheters with inner diameters in the range of 1.4 mm withstand flow rates up to 20 cc per second without rupturing. Since the injection rates used in visceral angiography are in the range of 5 to 15 cc per second, this is entirely adequate. Finally, most of the polyethylene catheters on the market have excellent radiopacity.

Teflon can withstand high injection pressures and has been useful in aortography. It is stiff, however, and when used to catheterize branches of the aorta can easily tear intima or perforate arteries. Moreover, Teflon is difficult to shape and taper, requiring exact temperatures. The injection rates and pressures required for visceral angiography are low enough so that Teflon catheters are unnecessary.

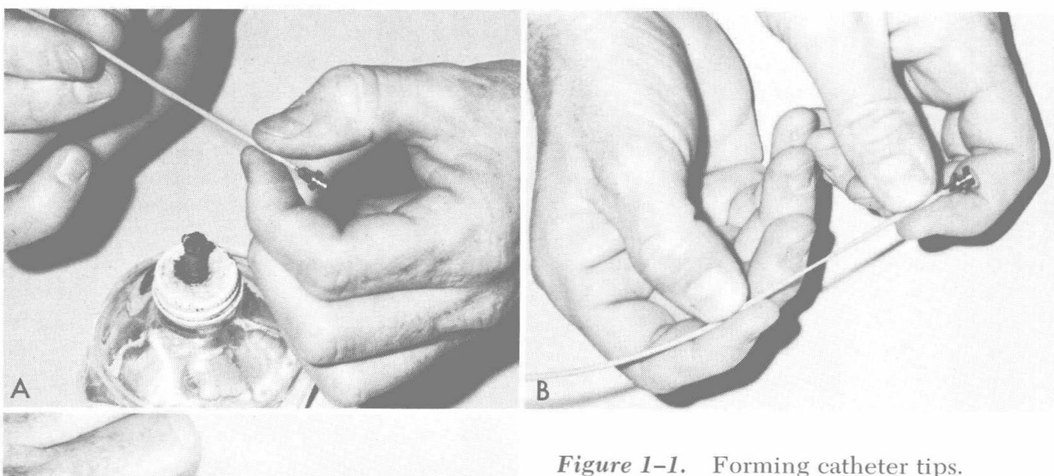
Polyurethane also has limitations as a catheter material. It has a high coefficient of friction, and unless specially coated, polyurethane catheters generate a great deal of resistance as they pass through the skin and as guide wires are passed through them during catheter exchange. For this reason Teflon-coated guide wires should always be used with polyurethane catheters. One possible advantage of polyurethane compared with other catheter materials is its smooth surface, particularly when coated. Although the relationship between the surface of a catheter and its thrombogenicity has not yet been demonstrated, polyurethane has been shown to be less thrombogenic than polyethylene (Durst et al., 1974). However, catheter thrombosis may soon become a less frequent complication of angiography. The use of total body heparinization has decreased the incidence of catheter-related thrombosis (Wallace et al., 1972), and heparin-bonded polyethylene catheters will soon become available commercially.

Recently, polyethylene and polyurethane catheters with excellent torque control have been introduced. Torque control has been achieved by placing a metallic mesh between the layers of extruded plastic. This mesh extends throughout the body of the catheter, ending several centimeters before the tip, so that the tip of the catheter can be formed into the desired shape. The degree of torque control offered by these catheters is unnecessary for most visceral procedures but may be helpful in certain superselective catheterization procedures, in patients with tortuous iliac arteries or ectatic aortas and in the catheterization of visceral arteries using the axillary approach.

Shaping Catheters

The tips of polyethylene catheters may be tapered over an alcohol lamp or hot air blower using the trocar of a thin-walled 18 gauge needle in the lumen (Fig. 1–1). Although a guide wire of the same size to be used for the catheterization can also be utilized, the resulting fit between catheter tip and guide wire is frequently too tight, causing the tip to bind as it is passed over the wire. With the trocar in place, the catheter material is rotated 360 degrees over an alcohol flame until the polyethylene begins to soften and expand slightly. The catheter is then removed from the flame, and the tip is pulled slowly and steadily. Drawing the tip while still over the flame generally results in the catheter material melting as it becomes thinner. If the rotation over the flame is not made through a complete 360 degrees, the catheter material softens unevenly, and the resulting tip will deviate to one side. When the desired taper is achieved, the trocar is removed; the catheter material is dipped in cold water to harden the plastic and sliced with a razor blade at the narrowest point. The end of the catheter is then slipped over a wire which has the desired curve, and the combination is dipped into boiling water (Fig. 1–2). When the catheter material is soft, it is removed from the water and placed in cold water to fix the shape. The forming wire is removed, and the distal part of the catheter is ready for use. The final step is flanging the proximal end of the catheter by holding it perpendicular to the alcohol flame and moving it in and out of the flame.

Blowers which direct a hot air jet of variable temperature for softening and shaping the catheter are available commercially. Also, a funnel can be inverted over a tea kettle of boiling water and the catheter sof-



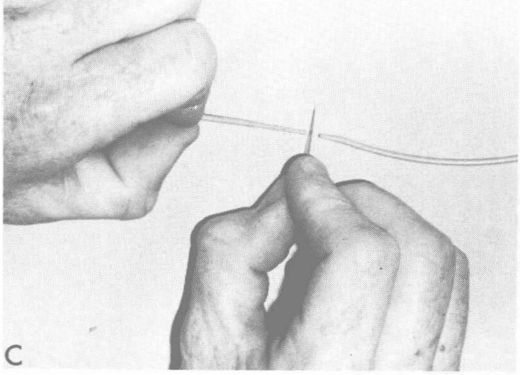


Figure 1–1. Forming catheter tips.

A. With a trocar of a thin-walled 18 gauge needle or a 0.038 guide wire in the lumen, the catheter is rotated through 360 degrees over an alcohol lamp until the catheter material begins to soften and swell.

B. The catheter is then removed from the flame and steadily and slowly drawn until the desired taper is achieved. The tip is dipped in cold water to fix the taper and the trocar or guide wire is removed.

C. The catheter is then sliced with a sharp razor blade at the desired point.

Figure 1–2. Forming bends in catheters.

A soft metal wire of approximately 0.035 inch in diameter is placed in the lumen of the catheter and the combination is bent into the desired shape. They are then dipped into boiling water for 2 to 3 seconds. It is important to keep the tapered tip out of the water, since it will soften and dilate if heated. The catheter and forming wire are finally dipped in cold water to fix the shape and the forming wire is removed.

tened over the resulting steam jet. The latter technique works particularly well with the thin-walled polyethylene catheters made by Becton-Dickenson.

The catheter shapes suitable for gastrointestinal angiography are shown in Figure 1–3. The same shape can be used for celiac, superior mesenteric and renal artery catheterizations. Distal to the renal arteries, the aorta tapers and is much narrower at the origin of the inferior mesenteric artery. The curve for the inferior mesenteric artery catheter, therefore, must have a shorter radius and a shorter distal limb.

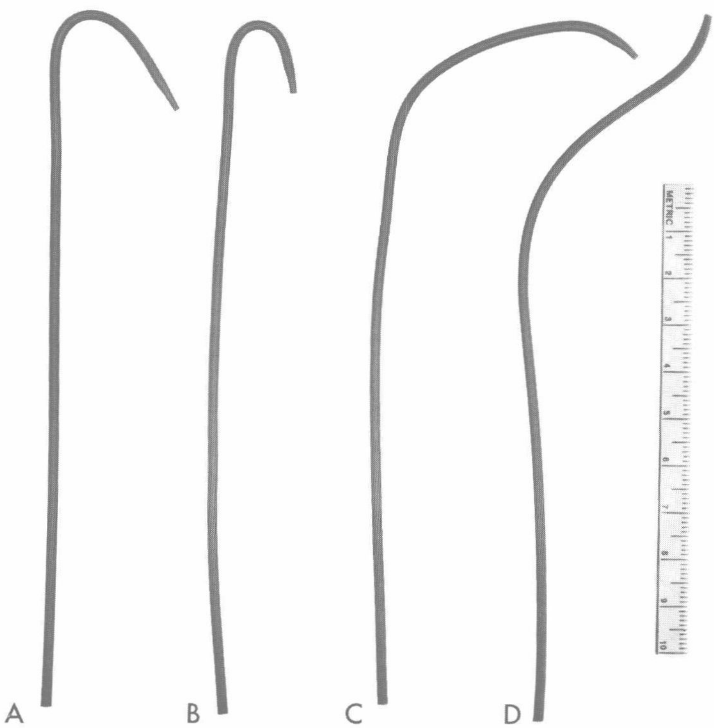


Figure 1–3. Shapes of distal catheter bends for visceral angiography.

A. Shape for celiac, superior mesenteric and renal angiography in an average patient. The distal limb must be lengthened for a patient with a dilated aorta and shortened for a child or small woman.

B. Shape for inferior mesenteric angiography in an average patient.

C. Shape for superselective angiography of the hepatic, splenic or gastroduodenal arteries.

D. Shape for left gastric artery or a dorsal pancreatic artery arising from the superior mesenteric artery.

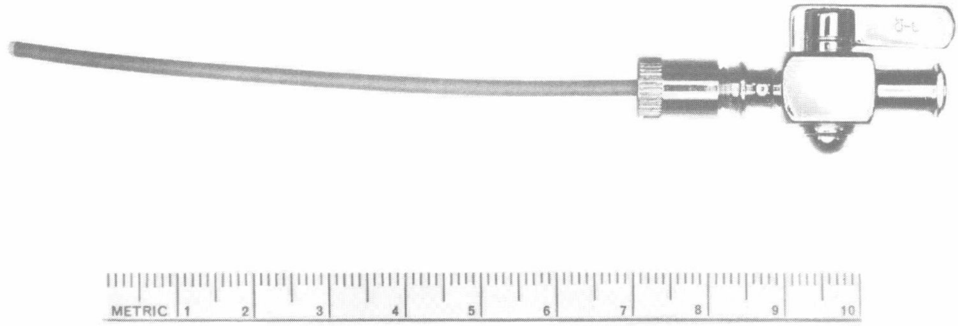


Figure 1–4. Combination of stopcock and flanged polyethylene catheter used in visceral angiography.

Stopcocks

The final piece of equipment necessary for performing the catheterization is the stopcock. This is best combined with the catheter as shown in Figure 1–4. Alternatively, a two-way stopcock can be attached to a female adapter. The latter combination is less desirable because a clot can form in the empty space between the adapter and the catheter.

GENERAL CATHETERIZATION TECHNIQUE

Over the years many different methods have been used for introducing contrast medium into visceral arteries. Until the development of the percutaneous transarterial Seldinger method, most of these procedures relied on introducing large doses of contrast medium into the aorta. The contrast medium would then flow into the aortic branches. These methods included translumbar aortography (dos Santos et al., 1931), large volume intravenous arteriography (Bernstein et al., 1960) and retrograde brachial artery injections (Sweet and Grismer, 1967). None of these methods have a place in modern visceral angiography because the concentration of contrast medium delivered to the visceral arteries from an aortic injection is inadequate to demonstrate the subtle vascular abnormalities of gastrointestinal diseases (Fig. 1–5). The only acceptable method is the selective injection of contrast medium into the celiac, superior mesenteric or inferior mesenteric artery.

Preangiographic Preparation of the Patient

The afternoon before the angiographic examination, the procedure should be explained to the patient, and he must be informed about both the potential diagnostic benefits to be derived and the potential complications which can occur. A mild sedative and an analgesic are given approximately a half hour prior to the examination. The combinations of drugs used are legion, but they should not be used to excess. They should also be used cautiously in children, old people and people with hepatic disease and jaundice. It is important that the patient be alert during the examination so that he can cooperate in holding his breath during the filming, and is able to complain of unusual pain that would indicate a complication. General anesthesia is not needed in visceral angiography. A few patients are hypersensitive to pain, and when this situation arises or if an older patient is extremely uncomfortable lying on his back for the duration of the examination, it is better to give small doses of a minor tranquilizer such as Valium during the examination rather than oversedate the patient prior to the examination.

Excessive withholding of fluids from the patient prior to the examination is dangerous. If left on their own, many nurses give the patient nothing by mouth after midnight, and the patient is dehydrated by the time he reaches the angiographic suite the following morning. It is preferable to specifically order a clear fluid breakfast. By doing so the increased dangers of high doses of contrast medium in dehydrated

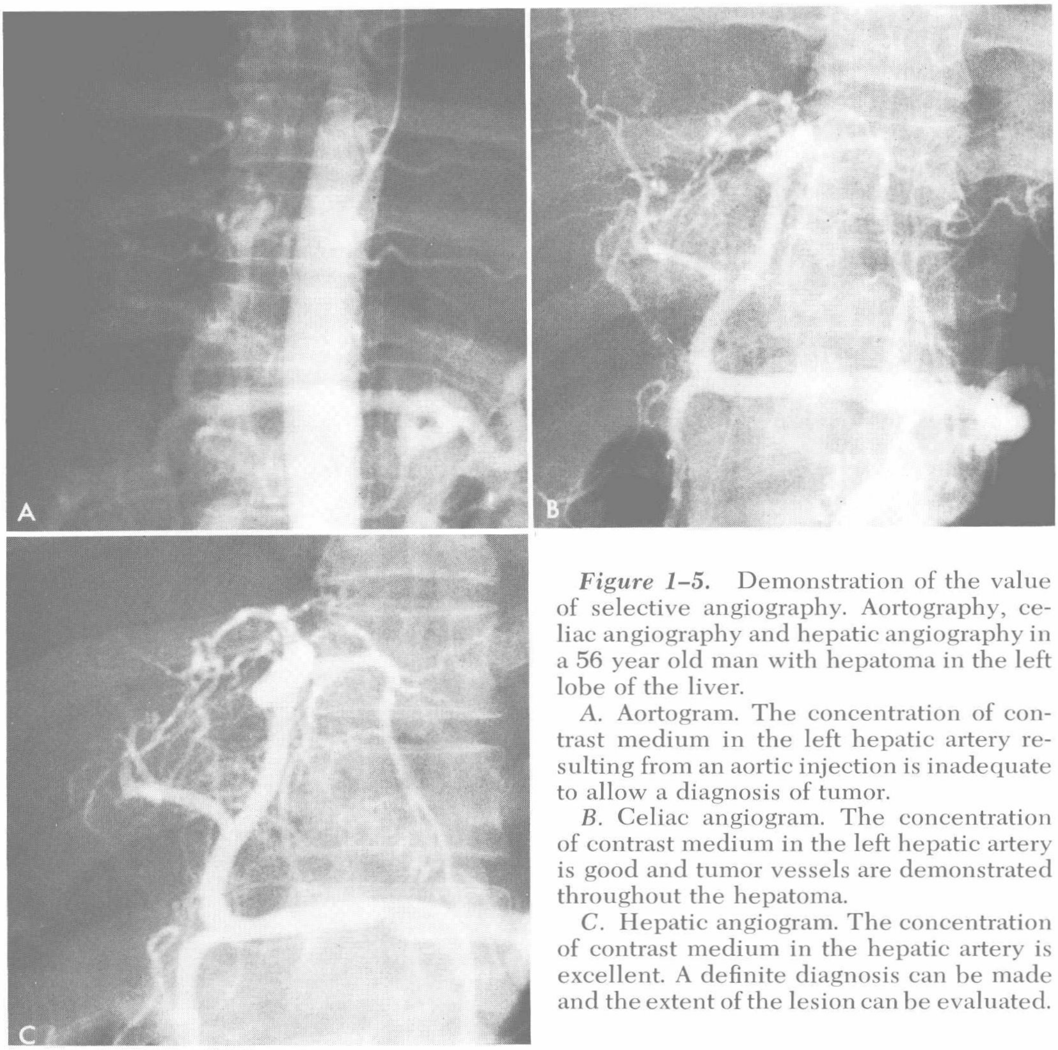


Figure 1–5. Demonstration of the value of selective angiography. Aortography, celiac angiography and hepatic angiography in a 56 year old man with hepatoma in the left lobe of the liver.

A. Aortogram. The concentration of contrast medium in the left hepatic artery resulting from an aortic injection is inadequate to allow a diagnosis of tumor.

B. Celiac angiogram. The concentration of contrast medium in the left hepatic artery is good and tumor vessels are demonstrated throughout the hepatoma.

C. Hepatic angiogram. The concentration of contrast medium in the hepatic artery is excellent. A definite diagnosis can be made and the extent of the lesion can be evaluated.

patients, particularly those with diminished renal function, are avoided.

Sites for Catheter Introduction

The technique in general use for catheterization of the visceral arteries was described by Seldinger in 1953. The method is shown in Figure 1–6 and can be used to introduce a catheter into any peripheral artery or vein. The arteries which have been used for gastrointestinal angiography have been the femoral, axillary and brachial. Of these, the femoral approach is by far the most preferable. It is the largest of the three arteries, and the catheter, when in place, compromises local blood flow the least. The patient can lie comfortably on his back during the examination, and a draw-sheet can be placed over the lower part of the angiographic table to maintain sterility. This artery is easily compressed and observed following the examination.

Occasionally, because of severe iliac atherosclerosis or the presence of aortofemoral grafts, the femoral artery cannot be used. The artery of choice then becomes the left axillary artery (Bron, 1966). This has several disadvantages when compared with the femoral approach but is still preferable to the brachial approach. The patient must lie with his arm behind his head during the

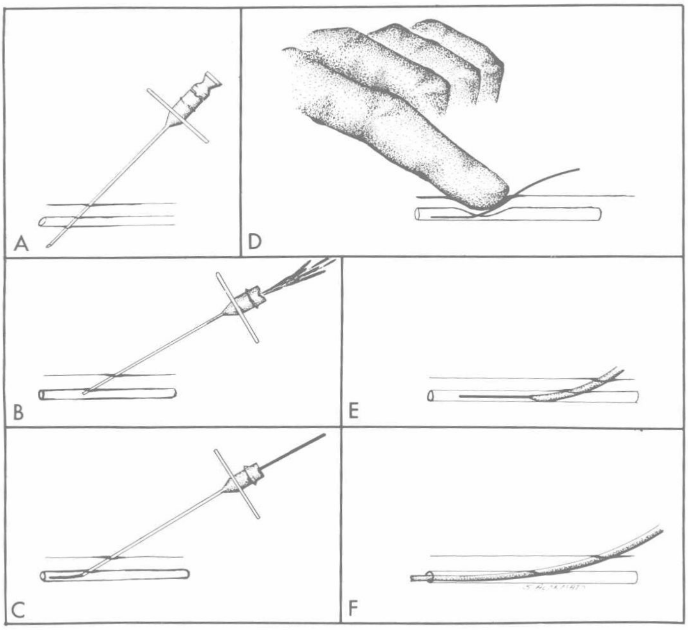


Figure 1–6. Seldinger technique for percutaneous angiography.

A. The needle is decisively thrust through both walls of the artery at an angle of approximately 45 degrees.

B. The trocar is removed and the cannula slowly withdrawn and depressed until blood spurts from the needle.

C. The guide wire is introduced through the cannula and passed into the aorta.

D. The cannula of the needle is removed from the guide wire and the puncture site compressed.

E. The catheter is advanced over the guide wire until the guide wire appears through the stopcock of the catheter. The guide wire and catheter are then advanced together into the artery. The guide wire is then held stationary while the catheter is fed over the guide wire into the aorta.

F. Finally, the guide wire is removed and the catheter is ready for positioning in the desired aortic branch.

examination. This position is tiresome and often results in decreased circulation to the hand and a sensation of the hand "going to sleep," which is difficult to differentiate from decreased circulation caused by spasm around the catheter. The axillary artery is smaller than the femoral artery, and the catheter may partially interfere with the blood flow. The puncture must be made through the brachial plexus. This is frequently painful and, rarely, results in nerve damage. The axillary artery is much more mobile than the femoral artery and is harder to puncture. Finally, compression of the axillary artery following the examination may be difficult, and if a hematoma does occur, it is more difficult to control.

The brachial artery is the favored approach of the cardiac angiographer, who uses a cut-down technique. It is not suitable for selective visceral catheterization, however, because of the great distance and the large number of bends between the arterial puncture site and the artery to be catheterized. The more bends a catheter makes, the more difficult the tip is to control. Also, the brachial artery is small, and spasm frequently occurs around the catheter. Spasm may prevent advancing the catheter into the subclavian artery and may also cause thrombosis at the puncture site.

Arterial Puncture

The first step in catheterization is the palpation and marking of the pulse distal to the puncture site so that it can be monitored during the examination. This is the

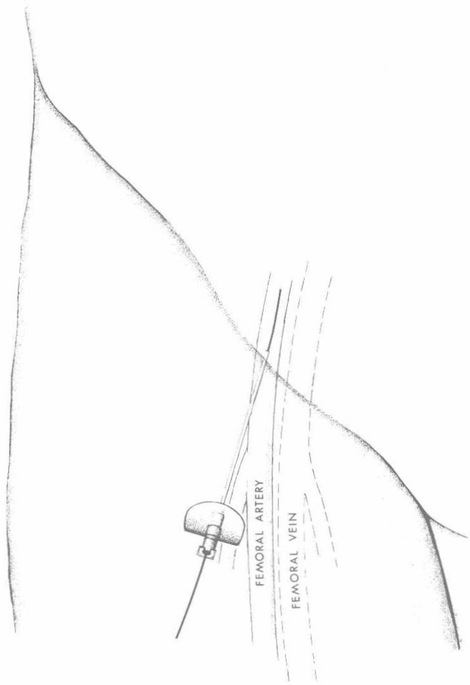


Figure 1–7. Femoral puncture site. The puncture should be made into the femoral artery at the inguinal crease or within 1 cm below the crease. The needle should be angled approximately 45 degrees in order to assure that the puncture is made into the common femoral artery.

dorsalis pedis, posterior tibial or radial artery, depending upon the approach. Monitoring may be done by intermittent palpation or with an inexpensive Doppler unit, which provides a continuous signal indicating the presence and quality of the pulse. The puncture site is then selected by palpating in the groin or axilla for the pulse. In the groin the best site for puncture is the inguinal crease (Fig. 1–7). A more caudal puncture may enter the superficial femoral artery, resulting in an increased incidence of thrombosis at the puncture site, especially in older patients. In an obese patient it is especially important to make the puncture into the inguinal crease since this is the shortest distance between the skin and the artery. Problems associated with passing a catheter to the artery through a great deal of fat are thereby lessened. The axillary artery should be punctured distally (laterally in the axilla), since it is difficult to compress the artery following a puncture made medially, toward the chest wall (Fig. 1–8).

When the puncture site is selected, the area is shaved, washed with Betadine and isolated with sterile towels and drapes. The area around the puncture site is then anesthetized with 10 to 15 cc of local anesthetic. A skin wheal is first made with a 25 gauge needle over the puncture site. The remaining anesthetic is placed on either side of the artery with a 22 or 23 gauge needle; 5 to 7 cc is deposited deep, behind the artery. The most important part is the deep deposition of local anesthetic; infiltration above the artery alone is not adequate to prevent pain. Finally, a 3 mm incision is made in the skin with a scalpel blade. This should extend through the subcutaneous tissues.

Some debate has occurred about the relative value of a through-and-through puncture of the artery versus puncture of the anterior arterial wall only. A through-and-through puncture does not increase the complication rate and generally can be done with one attempt; an anterior wall puncture may require more attempts and in inexperienced hands can lead to subintimal guide wire passage. In general, an anterior wall puncture in an elderly, thin patient with an ectatic femoral artery is fairly easy, and we generally do this in such a patient.

The puncture technique is as follows: the index and middle fingers of the left hand are placed below and above the puncture site respectively, and the pulse is palpated. The needle is then advanced steadily along the course of the artery at approximately a 45 degree angle to the artery. When the needle comes up against the artery, the pulsation will be transmitted through the needle. If the thumb of the right hand is against the needle hub, the pulsation can be felt, permitting central positioning of the needle. When central placement of the needle is obtained, the examiner makes a short, decisive thrust of the needle through both arterial walls. The trocar is removed, and the hub is depressed slightly. The needle is slowly withdrawn until blood spurts through the needle. If the needle is positioned well in the lumen of the artery, the blood spurt is strong and

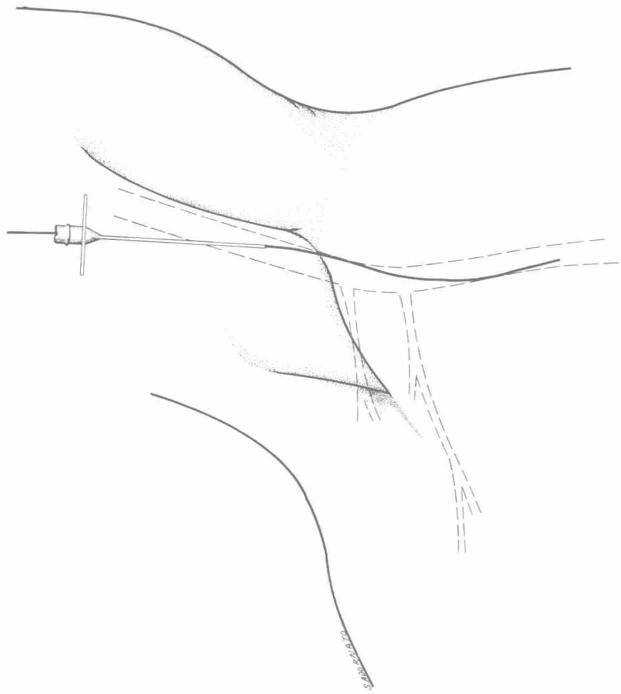


Figure 1–8. Axillary puncture site. The puncture of the axillary artery should be made as far laterally in the axillary crease as the artery is well palpated. The axillary artery is more mobile than the femoral artery and extending the arm over the head helps stretch and straighten the artery. With the arm over the head, the axillary artery generally lies just under the pectoral fold.

continues, though diminished, through diastole. If the needle is too near a wall or the tip is partially occluded by an atherosclerotic plaque, the spurt of blood is short and ceases during diastole. Another indication of a puncture too near the lateral wall of the artery is a single spurt of blood through the needle as it is withdrawn. If either of these situations occurs, the needle should be completely withdrawn and the artery compressed for 5 minutes. The process should then be repeated at a slightly different angle of insertion. One should not reinsert the trocar and make an immediate repuncture of the artery, as is frequently done for veins, since a hematoma may develop during the procedure. Occasionally, venous blood will return as the needle is withdrawn. The examiner should not assume that he is medial to the artery and quickly pull out the needle. He should continue slow withdrawal, since the vein occasionally lies behind the artery.

Guide Wire Insertion

The soft end of the guide wire is inserted through the needle into the artery. No attempt should be made to pass a guide wire through a poorly positioned needle, since this may result in the raising of a subintimal flap or laceration of the artery. The passage should be perfectly smooth into the abdominal aorta. If any resistance is encountered during the passage of the guide wire, fluoroscopy should be used immediately to determine what is hindering the passage. Occasionally, a slight withdrawal of the wire and reinsertion will result in a free passage into the aorta. The guide wire should never be forced forward against resistance. If the standard guide wire cannot be passed through a tortuous iliac artery or past atherosclerotic plaques, then a specially shaped wire should be substituted. Prior to exchanging the guide wire, the needle should be advanced over the wire so that it has a position in the lumen of the femoral artery well beyond the puncture site. On occasion, when advancing the guide wire is difficult or painful, fluoroscopic observation reveals that it is passing laterally into the deep circumflex iliac artery instead of medially. This generally causes the patient pain at the point of resistance. When this occurs, the guide wire should be drawn back into the needle and

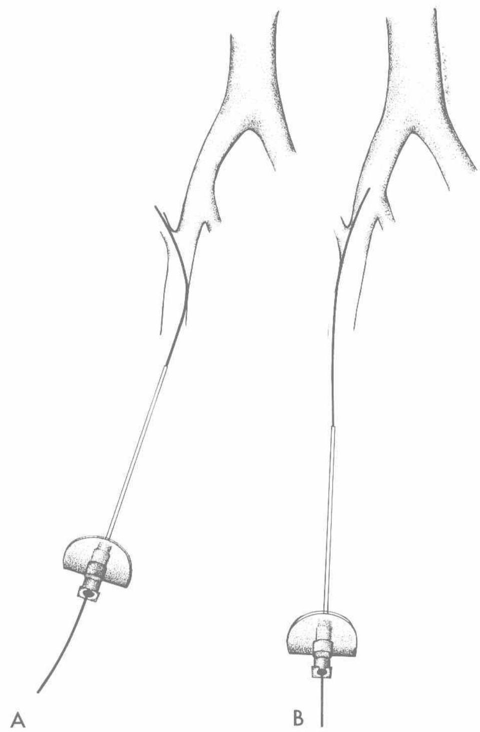


Figure 1–9. Redirecting a guide wire entering the deep circumflex iliac artery.

A. Occasionally the guide wire passes cranially and laterally, entering the deep circumflex iliac artery.

B. By directing the needle and guide wire slightly laterally, the guide wire bounces off the common femoral artery before reaching the deep circumflex iliac artery and is directed medially, passing freely up the iliac artery to the aorta.

the tip of the needle directed laterally (Fig. 1–9). Although it seems contradictory, this maneuver generally causes the guide wire to bounce off the lateral wall of the femoral artery and to point medially toward the common iliac artery.

With the axillary approach, the guide wire occasionally passes down the subscapular or lateral thoracic artery instead of continuing into the subclavian artery. When this occurs, the arm can be brought into more of a right angle position relative to the body, putting the axillary and subclavian arteries more in a straight line and resulting in smooth passage of the guide wire centrally.

Coping with Tortuous Iliac and Subclavian Arteries

Several methods have been devised to negotiate atherosclerotic and tortuous iliac arteries. The original method described by Baum and Abrams (1964) used a catheter with a tight J-shaped tip. A J-shaped guide wire was later substituted for the catheter (Judkins et al., 1967), eliminating a catheter exchange. The tightly curved end of the tip of the J-shaped guide wire bounces off atherosclerotic plaques and follows tortuous vessels very well, while the standard, straight tip tends to catch on the irregular surfaces of the iliac vessels (Fig. 1–10). Another wire which has been used for negotiating tortuous or atherosclerotic iliac or subclavian arteries has a 10 to 20 cm soft end (Rossi and Verdu, 1966). When the tip of this guide wire catches in an irregular area, it buckles into a "J," which then freely passes the atherosclerotic area.

Catheter Insertion

When the guide wire reaches the upper abdominal aorta, the needle is removed. The distal three fingers of the left hand should compress the artery at the puncture site as soon as the needle is withdrawn. The thumb and forefinger firmly grasp the guide wire so that it is not pulled out as the needle is taken off or the catheter put on. The guide wire is then wiped free of blood with a dry sponge. Guide wires should always be wiped free of blood after needles and catheters are removed from the artery during puncture or catheter exchange to help prevent clotting on the wire during reinsertion of the catheter. Many examiners prefer the use of a wet sponge for this purpose, but we use dry sponges for two reasons. First, wet sponges on the field soak through to the nonsterile underlying sheets and decrease the sterility of the field. Second, it is easier to manipulate the catheter when all the equipment is dry. The catheter is advanced over the guide wire until the tip is at the skin. The guide wire must have appeared through the stopcock. To introduce the catheter through the soft tissues into the artery it should be grasped