Interventional Radiology: Principles and Techniques

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Preface

Since its introduction, fluoroscopy has permitted controlled passage of radiopaque materials within the body. Traditionally, fluoroscopy was used to provide diagnostic information about lesions otherwise inaccessible to dynamic imaging and thus reduced the need for many exploratory surgical procedures. Entry into the body can be achieved through the body's natural orifices, cutaneous fistulas, and surgical drainage tracts or by direct percutaneous approaches. With the introduction of the Seldinger technique in 1953, a safe and simple method of catheter entry into the vascular system became practical. Since then, considerable expertise has been gained in the techniques of manipulating angiographic catheters throughout the arterial and venous systems so that direct catheterization into the blood vessels supplying virtually every organ is now possible. During the past five years, percutaneous approaches also have been developed to permit access into other systems, such as the biliary and genitourinary tracts, and catheterization techniques have been modified for use outside the vascular tree.

Over the past 15 years, radiologists have combined their ability to observe and control manipulations within the body with their ability to perform a variety of new radiologic techniques. A broad range of interventional procedures has evolved that are becoming widely accepted as alternative therapeutic approaches to the management of disease processes affecting almost every organ system. The term *interventional radiology* describes this relatively new field. It is a field that is rapidly changing and expanding as new methods are developed. With the increasing number of interventional procedures has come a dramatic change in the radiologist's clinical responsibilities. Because the new radiologic techniques not only provide diag-

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noses but also afford treatment, which in many cases is comparable to surgical alternatives, the interventional radiologist's role now closely parallels the surgeon's. Therefore, radiologists cannot isolate themselves, confining their interest to radiologic and procedural considerations but, like surgeons, must provide extensive pre- and post-procedural care.

Interventional radiology services are being established in various medical centers to provide this new type of care. These services are staffed not only with specially trained radiologists but also with skilled technologists and nurses. In our own institution, the Hospital of the University of Pennsylvania, a clinical interventional radiology service has evolved that functions like a surgical subspecialty. Patients who are directly referred for radiologic intervention are admitted to this service and followed by its staff. Patients who are already under the care of another clinical service become a joint responsibility of both services. Throughout their hospital stay, the patients are seen daily on ward rounds. Following their discharge, many patients are given long-term care by the interventional radiology service. Follow-up is especially important for the many patients being treated with permanent drainage tubes; these patients are seen at regular intervals for routine catheter maintenance.

In this book we describe the techniques we commonly employ to perform the various interventional radiologic procedures. We are aware, of course, that alternative methods are being used successfully in other medical centers and that new techniques are always evolving, but we hope that by discussing a unified approach used in one medical center, we will enable radiologists already familiar with invasive diagnostic techniques to provide their patients with these interventional radiology services.

E. J. R.
G. K. M.

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Ernest J. Ring

In 1963, Baum and Nusbaum recognized that, regardless of etiology, bleeding occurred because of a disruption in the wall of a blood vessel and, therefore, like other types of vascular pathology could be demonstrated angiographically [1]. In a series of experimental studies, these investigators showed that active blood loss could be readily visualized at angiography because small amounts of radiopaque contrast medium extravasated with the blood [2, 3]. They then began accumulating extensive clinical evidence documenting the practical value of selective arteriography in localizing bleeding from sites throughout the gastrointestinal tract. In 1967, Baum and Nusbaum proposed that the angiographic catheter could be used not only to demonstrate the extravasation but also to selectively infuse vasoconstricting drugs to treat the bleeding [4].

In many ways, this progression from a diagnostic to a therapeutic application of the angiographic catheter marked the beginning of interventional radiology. The technique not only evolved into a useful clinical tool for managing bleeding, it also led to important changes in the scope of the radiologist's involvement in patient care. With the advent of angiographic techniques for treating bleeding, the radiologist became intimately involved in resolving complicated clinical problems. Diagnostic radiologists were not only coming into the hospital at all hours for emergencies, but began making regular ward rounds and demonstrating their interest and effectiveness over a broad range of clinical responsibilities. These changes in the radiologist's role led physicians in other specialties to an increasing acceptance of the diagnostic radiologist as a purveyor of innovative modes of therapy and attracted a group of physicians into the field who were committed to expanding the therapeutic applications of fluoroscopically positioned catheters. An atmosphere evolved which facilitated the widespread implementation of the other interventional techniques that were subsequently introduced.

In this chapter, we review both the current status of the angiographic approaches to managing bleeding and the broader applications of transcatheter vascular occlusion therapy. Most of the skills required to perform these procedures are modifications of standard angiographic catheterization techniques already familiar to most radiologists. Therefore, this discussion emphasizes the matters most pertinent to therapy, especially the pitfalls which may be encountered in attempting to control acute bleeding angiographically.

ANGIOGRAPHIC LOCALIZATION OF A BLEEDING SITE

Although it is only one of several methods of locating a source of gastrointestinal blood loss, and although it has several limitations, selective angiography continues to be an important and commonly used clinical tool. The procedure may be performed on severely ill patients, and it requires little cooperation from the patient. No special preparation is necessary, and an accurate diagnosis can be made despite the presence of large amounts of blood in the gastrointestinal tract. The radiographic criteria are straightforward, and the diagnosis is readily established with minimal interobserver variation. The widespread use of angiography in bleeding patients has led to a number of important clinicopathologic observations (e.g., of angiodysplasia of the colon) and has provided new and sometimes surprising information about the common causes of bleeding (e.g., the relative frequency of right and left colonic diverticular bleeding and the arterial nature of traumatic pelvic bleeding).

Rate of Detectable Bleeding

In their early experimental studies, Baum and Nusbaum showed that selective arteriography could demonstrate arteriocapillary bleeding at rates greater than or equal to 0.5 ml per minute [1–3]. It is interesting that this rate, which has been so widely quoted in the literature as the lower limit of detectable bleeding, actually reflected a limitation of Baum and Nusbaum's experimental model. Since their technique was incapable of consistently maintaining blood loss at less than 0.5 ml per minute and since they were able to identify extravasation at this rate, it is likely that even lower rates of blood loss might actually be detectable.

Radiographic Appearance of Bleeding

Typically, bleeding is first detected during the arterial phase of a selective arteriogram when a localized puddle of contrast material begins to collect. As filming continues, extravasation becomes increasingly apparent; it is especially obvious at the end of the angiographic series, when all the intravascular contrast has washed out (Fig. 1-1). The radiographic appearance of extravasated material varies with the rate of bleeding and the nature of the space in which the blood is collecting. Very brisk, continuous bleeding

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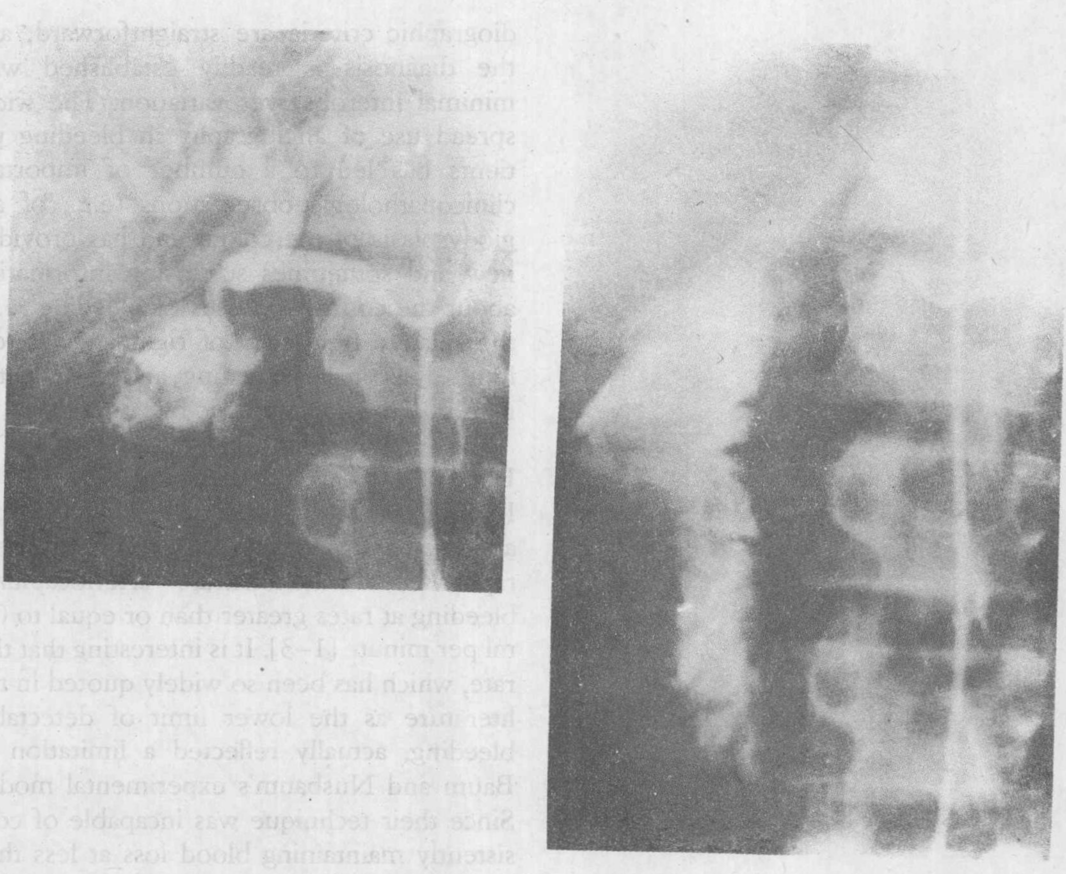


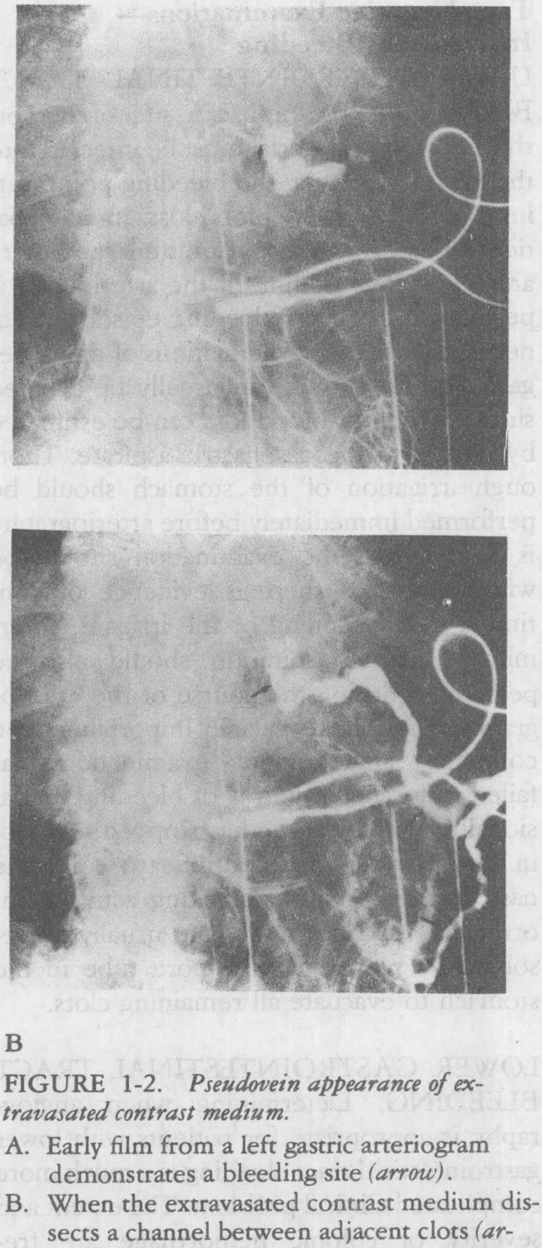
A

B

FIGURE 1-1. *Angiographic appearance of massive bleeding.*

A. Hepatic arteriogram demonstrates an amorphous "puddle" of contrast medium extravasating from the gastroduodenal artery.

B. The extravasation persists after all the intravascular contrast medium has washed out. There was enough extravasation in this instance to outline the mucosa of the duodenal loop.



B

FIGURE 1-2. *Pseudovein appearance of extravasated contrast medium.*

A. Early film from a left gastric arteriogram demonstrates a bleeding site *(arrow)*.
B. When the extravasated contrast medium dissects a channel between adjacent clots *(arrows)*, it creates a tubular appearance similar to that of a venous structure.

produces the largest, most easily seen collections and may even provide excellent opacification of the mucosa of the gastrointestinal tract. Small amounts of extravasation appear as localized collections; usually the collections are amorphous but occasionally they outline an ulcer crater or a colonic diverticulum. If the area around the site of hemorrhage is filled with clotted blood, continued bleeding can dissect a channel between adjacent clots. Contrast extravasating into such a channel can create an elongated, tubular configuration reminiscent of a venous structure (Fig. 1-2). Such a "pseudovein" is easily distinguished from a vascular malformation because the extravasated contrast medium persists beyond the venous phase of the arteriogram [5]. Within a few minutes, most of the contrast material which has extravasated into the gastrointestinal tract is diluted and carried distally by peristalsis so that it does not persist between sequential injections. However, if the bleeding is extraluminal (e.g., as in extraperitoneal hemorrhage following pelvic trauma), the extravasated contrast medium may persist for long periods of time. Residual opacification from previous injections may complicate the interpretation of subsequent posttherapy arteriograms.

PITFALLS IN THE ANGIOGRAPHIC DIAGNOSIS OF BLEEDING

Every angiographer has had the frustrating experience of examining a patient thought to be actively bleeding only to fail to find a site of extravasation. In the following paragraphs, we will consider the common causes of true-negative and false-negative angiographic examinations in the bleeding patient.

True-Negative Examinations—Intermittent Bleeding

UPPER GASTROINTESTINAL TRACT BLEEDING. To localize a site of hemorrhage, contrast material must be injected into the vessel supplying the bleeding point during a period of active blood loss. In many patients, hemorrhage is intermittent, and there are no positive findings if the arteriogram is performed between bleeding episodes. Unnecessary negative examinations of the upper gastrointestinal tract can usually be avoided since the rate of blood loss can be estimated by observing the nasogastric aspirate. Thorough irrigation of the stomach should be performed immediately before arteriography is begun, and the examination should be withheld unless there is evidence of continued blood staining of the irrigant. Intermittent gastric aspiration should also be performed during the course of the arteriogram; aspiration is especially important after a complete angiographic examination has failed to localize a source of bleeding. Occasionally, after bleeding has stopped, old clot in the stomach may continue to color the nasogastric aspirate, mimicking active hemorrhage. Any uncertainty can usually be resolved by placing a large-bore tube in the stomach to evacuate all remaining clots.

LOWER GASTROINTESTINAL TRACT BLEEDING. Determining when angiography is appropriate for patients with lower gastrointestinal tract bleeding is a much more complicated clinical problem. The extent and severity of colonic hemorrhage are frequently difficult to evaluate clinically since blood often continues to pass through the rectum for several hours after bleeding has actually ceased. In addition, since lower gastrointestinal tract bleeding commonly affects patients who are elderly and whose condition is difficult to stabilize, monitoring vital signs may result in an overestimate of the degree of ongoing blood loss. In the early 1970s, when angiographic techniques were first being applied to the management of lower gastrointestinal tract bleeding, angiography was usually withheld until massive hemorrhage had occurred; commonly, as many as 5 to 7 units of blood were transfused before arteriography was performed. Since spontaneous hemostasis is unlikely to occur in patients with this degree of bleeding, the incidence of positive examinations was great [6]. With the increasing acceptance of angiographic therapy, patients were referred for angiography at much earlier stages. Consequently, many patients who had spontaneously stopped bleeding were being studied, and the number of negative examinations greatly increased.

Screening Patients for Angiography with a Radioisotope Bleeding Scan

Alavi has developed a radioisotopic examination which can demonstrate active hemorrhage and which is very useful in selecting those patients with lower gastrointestinal tract bleeding most likely to benefit from angiography [7]. The technique is simple and noninvasive, and it is capable of demonstrating arterial and venous bleeding at rates as low as 0.1 ml per minute. Scintigraphic scanning of the abdomen is begun immediately after the intravenous injection of 10 mCi of ^{99m}Tc sulfur colloid (a reticuloendothelial imaging agent used for liver-spleen scanning). When the circulating isotope reaches the bleeding point, a small amount extravasates, and with each recirculation increasingly smaller amounts of radioactivity are deposited at the site of hemorrhage. At the same time, the background activity in the bloodstream decreases because ^{99m}Tc sulfur

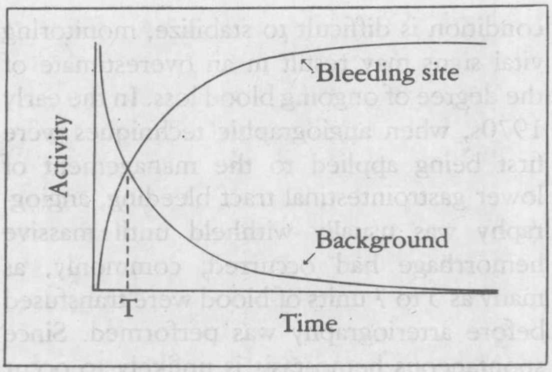


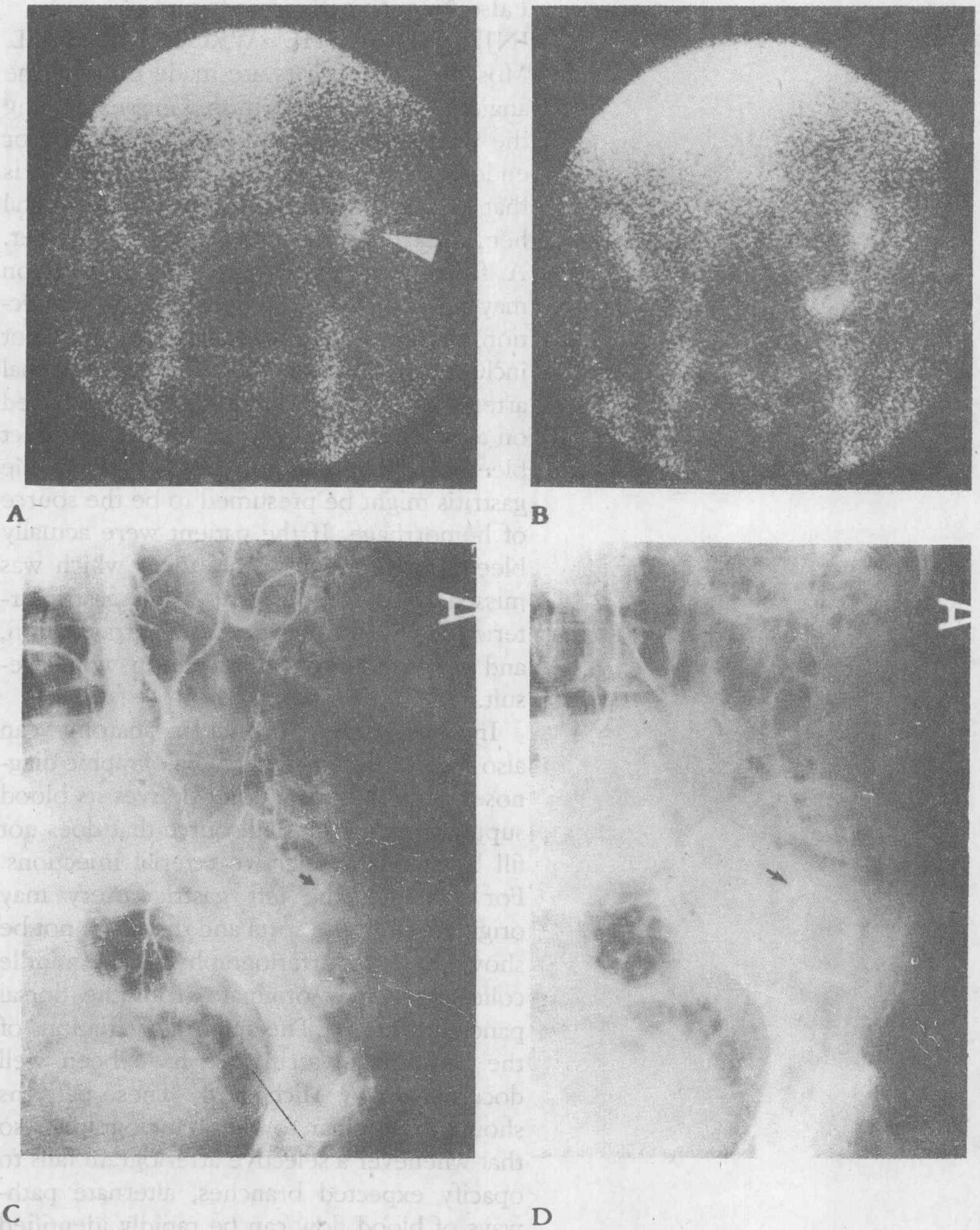
FIGURE 1-3. *Radioisotope bleeding scan.* After intravenous injection of 10 mCi of ^{99m}Tc sulfur colloid, extravasated activity is present at the bleeding site. At the same time, the background activity is decreasing. Contrast is reached at the point where the two curves cross *(T)*.

colloid is rapidly cleared from the circulation by reticuloendothelial cells in the liver, spleen, and bone marrow. Within 5 to 10 minutes, a contrast is usually reached between the bleeding site and the background (Fig. 1-3). Because of the overlying liver and spleen, bleeding at the hepatic or splenic flexures may not be apparent initially. If no extravasation is seen on early scans, the examination is continued to allow peristalsis to carry the extravasated radionuclide away from these high-activity organs. This radioisotope technique has proved to be a highly effective screening procedure, and, if employed in questionable cases of lower gastrointestinal tract bleeding, it markedly reduces the number of negative angiographic examinations (Fig. 1-4).

FIGURE 1-4. *Radioisotopic demonstration of a bleeding left colonic diverticulum.* ▶

A. An early scan demonstrates a bleeding point in the left lower quadrant *(arrowhead)*. Activity in the bone marrow of the pelvis helps to provide anatomic landmarks.
B. A subsequent scan shows progression of the extravasated activity to outline the sigmoid colon.
C. Inferior mesenteric arteriography was performed immediately after the scan was completed. A punctate area of extravasation is seen in the descending colon corresponding to the site shown on the radioisotope scan *(arrow)*.
D. The extravasated contrast medium persists after the intravascular contrast medium has washed out *(arrow)*.

Note: This amount of extravasation is the minimum detectable by angiography, but it is readily demonstrated by the radioisotope technique.



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